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THE CITY ENGINEER'S PROBLEM

By

HARLAN HAMMOND EDWARDS

B.S. in C.E., University of Illinois, 1917

THESIS

ted in Partial Fulfillment of the Requirements for the

Degree of Civil Engineer

in

THE GRADUATE SCHOOL

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THE CITY ENGINEER'S PROBLEM

- - - -

INTRODUCTION

Many years ago, history tells us, the engineer's problem was one greatly like that of today. Marcus Vitruvius, the Roman architect and engineer in 150 B.C., says of the engineer: "He should be a good writer, a skillful draughtsman, versed in geometry and optics, expert at figures, acquainted with history, informed on the principles of natural and moral philosophy, somewhat of a musician, not ignorant of the sciences, both law and physics, nor of the motions, laws and relations to each other of the heavenly bodies. . . . . Moral philosophy will teach him to be above meanness in his dealings, and to avoid arrogance. It will make him just, compliant and faithful to his employer, and what is of highest importance it will prevent avarice gaining an ascendency over him, for he should not be occupied with thoughts of filling his coffers nor with the desire of grasping everything in the shape of gain, but by the gravity of his manners and a good character, should be careful to preserve his dignity."

Such requirements are in effect today. The successful engineer must be one well read, thoroughly conversant with the latest developments of his art, yet having a good knowledge of other sciences and of letters, while above all he must be a

diplomat and a gentleman, having a mind of his own, and the ability to bring others to his own way of thinking.

The city engineer's problem, similarly, is a complex one, which involves the possession of all the attributes of an engineer combined with an unlimited supply of patience and perseverance. It requires the possession of thorough confidence in himself and in his ability to "produce the goods". It necessitates the early acquisition of a thorough knowledge of the city and its needs. It presupposes the possession of the ability to make accurate surveys, economical designs, correct estimates, to lay out and superintend the construction of bridges, pavements, sewers, buildings, dams etc, and to back up his own judgment with undisputable facts, when need be.

The successful solution of the city engineer's problem includes, still further, the ability to handle men and to gain their good will, while the possession of tact, judgment, unlimited patience and good nature in handling the general public is of greatest importance. A thorough knowledge of municipal law and court practice in local improvement cases is fundamental, and the lack of it may prove fatal to many of the engineer's undertakings. In all his work, the engineer must prove himself a capable executive. He must be visionary and imaginative, yet he must have the power to carry out his dreams to a successful and practical realization.

As one who is largely responsible for the development of the city's resources, and the one, of all, who should plan his work for the future, he should adopt as his motto the oft

repeated injunction of Daniel Burnham, the great architect and city planner: "Make no little plans; they have no magic to stir men's blood and probably they themselves will never be realized. Make big plans; aim high in hope and work, remembering that a noble, logical diagram once recorded will never die, but long after we are gone will be a living thing, asserting itself with ever-growing insistency. Remember that our sons and grandsons are going to do things that would stagger us. Let your watchword be order, and your beacon beauty."

I. THE ENGINEER'S FIRST ACQUAINTANCE WITH CITY WORK.

Familiarity with City Necessary

Upon taking office, the new city engineer finds himself almost as a stranger in a strange land. New locations, new conditions, different people and different laws often serve to confuse his mind and render immediate and effective service impossible. He must, therefore, endeavor to acquaint himself at the earliest possible moment with the general lay-out of the city, with the street names and their locations, with the laws and ordinances relative to his work or his authority, and with the necessary legal procedure in the various classes of work which come under his direction. The knowledge of all these things is essential to the adequate and satisfactory service which is expected from him.

Familiarity with the street names and topographic details of the city and vicinity is the first requirement. Since the engineer's work deals largely with improvements to the streets and alleys, or with structures lying within their limits, a thorough knowledge of all their characteristics and hazards is needed that he may deal with them intelligently.

Knowledge of Engineer's Powers and Duties Required.

Since the powers and duties of the city engineer are fixed and limited by law, it behooves him, therefore, to ascertain their nature, that in the performance of his duties none will be neglected, yet that he will not exceed his authority. Although every city is guided by the advice of

legal counsel, many activities of the municipality which are participated in by the engineer are so hedged about by laws and ordinances that a good working knowledge of these rules and restrictions is essential. Many steps and hours of labor can be saved at times by such familiarity with the requirements of the law.

Establishment of Confidence

Upon taking office the new city engineer must do all in his power to establish himself in the confidence and good graces of the various city officials and men prominent in civic life. Vitruvius evidently had this in mind when he said of the engineer "Moral philosophy will teach him to be above meanness in his dealings, and to avoid arrogance. It will not allow avarice to gain the ascendency over him - - but he by the gravity of his manners and a good character, should be careful to preserve his dignity." Professional poise or dignity is a quality few engineers possess, yet which all should covet and endeavor to attain.

In the adoption of a definite and a straightforward policy with regard to the conduct of his office in its relations with other departments and with the general public, the incoming engineer will have taken a long step toward the creation of good feeling and harmony. He should endeavor always to install into his subordinates the value of courtesy and a helpful spirit, and an appreciation of the fact that they are all, with him, public servants, ready and willing at all times

to help and advise the various citizens coming to them for information or assistance.

Need for Remedial Legislation

In the performance of daily duties, and in the enforcement of the various laws, ordinances and rules governing work of an engineering character, things occur frequently which indicate the need for remedial legislation, correcting abuses and obsolete practices. The city engineer should endeavor to secure the passage of new ordinances as soon as possible covering these needs and thus bring the city's engineering code thoroughly up to date. Such a need was found to exist in a small Illinois city when the writer took office. Pavement replacement operations, the proper performance of which was of great importance, were entrusted with no supervision to people having little or no experience in such work. The result was that many sunken places occurred in the city's pavement that were dangerous to traffic and a detriment to the pavement. After making a thorough investigation, an ordinance * was drawn up and passed regulating and limiting the performance of such work to experienced men employed by the city with certain provisions regarding the handling of the work. Several years of work under that ordinance have proved its value.

In sidewalk construction likewise, it was found that irresponsible persons had taken contracts for and laid many feet of concrete sidewalk under no supervision, and then

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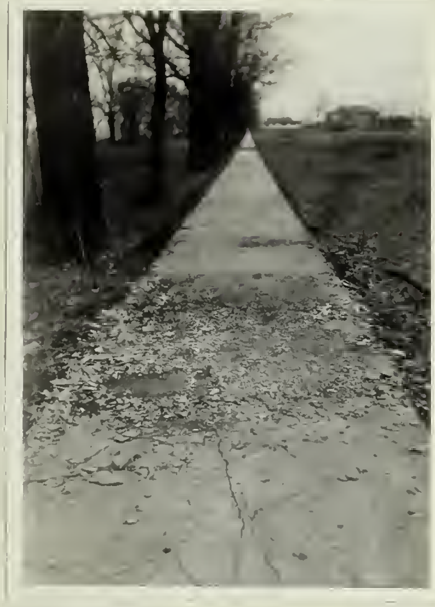
* See appendix P 94

suddenly left town. Time soon showed that the work had been "skinned" and the property owners defrauded. Here again was the need for more stringent regulation of work of this character, and the need for providing over a period of time,



After 4 months service.

a definite and adequate guarantee of all work laid. An ordinance ** was drafted, therefore, licensing all sidewalk contractors and providing a sufficient fund and bond that ample assurance would be given the people that such work would be done properly. Likewise, many other flagrant abuses of public confidence can be found, needing the early application of remedial measures.

Planning for the Future

Such needs as the foregoing, as well as needs for new work, can be ascertained by a survey of the condition of

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** See appendix P. 99

the city with regard for its needs for the future. Much repetition and waste of effort can be avoided by careful planning of new work as far in advance as possible. With the adoption of a rational program of work to be done, scheduled carefully over a period of years, plans can be made in a much better manner. Such work in the usual small city, as well as the large one, includes not only construction items, but also includes restrictional work such as the control of the smoke nuisance, traffic and parking problems, as well as the directional work in zoning, etc., accomplished by competent city planning. Planning for the future should be done in all cities, yet it is found in few.

II. THE CITY ENGINEER'S DUTIES.

The city engineer's duties are quite varied, embracing the making of surveys and setting grades, the responsibility for economical designs of all engineering structures, the inspection of such structures during construction, and the control of such structures and their maintenance after completion. They also include in many cities acting as engineer for and secretary of the Board of Local Improvements.

The extent and character of the duties of the City Engineer vary with the type of government in effect in the municipality, but oftentimes this variation exists also in different cities under the same form of government.

Surveys.

The making of surveys and the setting of grade stakes for new improvements of all kinds is the first duty of the city engineer. In some cities this is his chief occupation and warrants the title "City Surveyor" - which is in use in some places. In other places, however, his duties take on a much broader aspect, with surveying as a necessary, yet incidental part of the work. At all times, though, it is the city engineer's duty to give grades, when called upon, for all sidewalk construction, that new walks may be placed to such lines and slopes as will correspond most nearly to later improvements such as curbing and paving. Such work at times requires much thought and consideration, for on entirely unimproved streets, this involves the determination of the most logical pavement grade, the location of all drainage

structures, the decision as to the width of the parking space which shall be left between the sidewalk and the curb, and the adoption of a width of walk on this street which will be suited to the probable needs of the district for a period of ten or fifteen years hence. We also must give the grades on all paving, sewer or other work of public character, done by private contract.

Designs.

Upon him too, is placed the responsibility for the design of all engineering structures to be placed within the limits of the city's streets and alleys or on any public property. It is in this phase of the work that one is brought forcibly to the realization and appreciation of the fact that the city engineer must know something about more phases of engineering than does perhaps any other class of engineers. He must construct sewers, bridges, buildings, pavements, sidewalks; collect and dispose of street and domestic refuse, perhaps operate sewage treatment and water purification plants with their chemical and biological features, and must satisfy the citizens in general, and the 'powers that be', in particular, that he is "onto his job" in these and a dozen other lines.

Special Problems.

In any growing city, however, there come times when specialized knowledge along one line or another is necessary or at least desirable - such as for designing new

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PROBLEMS

and large sewerage or water supply systems, or solving unusual problems in existing ones; deciding on an extensive paving program; planning for the disposal of municipal refuse; for designing large bridges or buildings; or preparing a city plan for future development, etc. It is plain that unless he is an exceptional man, a city engineer cannot find time from all his regular duties to become a specialist in more than one of these branches, and only a 'super-man' could be a thoroly informed specialist in all of them.

Expert Advice.

When such specialized knowledge is required, therefore, it is no discredit to a city engineer if he ask that a specialist be employed to advise him; in fact, the discredit would lie in his being ready to risk the expenditure of the taxpayers' money without taking such advice. In case such expenditure is to be large, he ought to obtain such advice even though he himself is perfectly competent to design the work, considering it as a factor of safety, on the general principal that "two heads are better than one." In the professions of medicine and law this is well recognized, and no important case is considered properly handled unless a consulting physician be called in or more than one lawyer be employed upon it; and the better class of general medical practitioners are continually referring their patients to eye specialists, nerve specialists, etc.

There would seem to be little doubt but that city councilmen or others to whom the matter of employing a con-

sultant must be referred would readily recognize the logic of the above if it were properly presented to them, and would appreciate the broadminded attitude of their city engineer in asking that he be authorized to obtain advice with a view to making it more certain that the work contemplated would be creditable to them and to him. But to have the work prove a partial or total failure because of the neglect of the engineer to request advice, might cause a setback to his advancement in the profession; and justly so, for good judgment is as necessary in this respect as in the purely engineering functions of designing and constructing public work.

Inspection of Construction.

Control and inspection of the construction of all municipal works of engineering character falls upon the shoulders of the city engineer and it is here that success or failure can be written upon the record of the engineer quicker and easier than at any other time. It is here also, that the engineer and his associates are beset with requests for "jobs" from political henchmen of all kinds desiring to become "inspectors" or anything else just so they have a soft snap backed by the recommendation of the mayor, one or more alderman, or political bosses. To turn these political parasites down, and yet retain the good will of their sponsors is a problem of tact and diplomacy worthy of a statesman. Fortunate indeed is the engineer who has succeeded in having a reputable firm of consulting engineers retained on the special jobs not only to aid in their design, but also to super-

vise or inspect their construction.

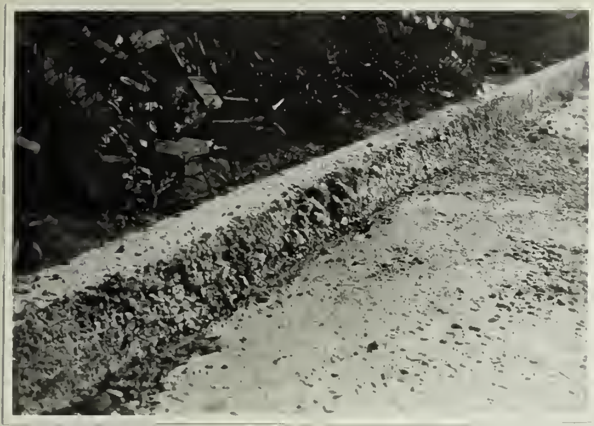
On the smaller jobs, however, it is often necessary to use men as inspectors who have been selected thru political effort, rather than by training and experience. With sufficient support from the mayor and city council, some of these men can be trained to be watchful and efficient inspectors, well informed as to their powers and duties and always alert in the interests of the city. Others, however, do not want to learn, and must be watched until a good opportunity arises to discharge them. Continual viligance is required under these circumstances that a satisfactory piece of work be done.

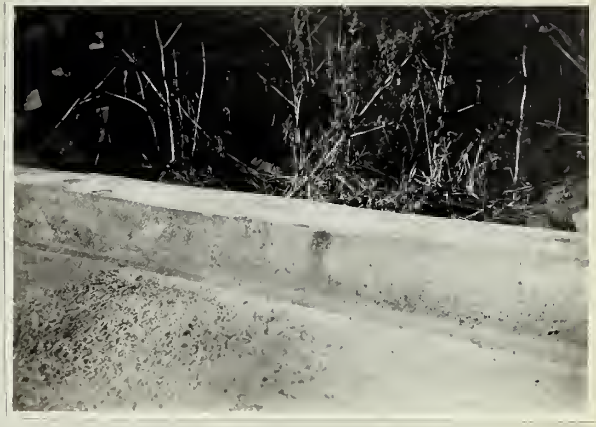
Experienced Men Cost Money.

Experience shows that in hiring men, the principle applies that usually you get just what you pay for. If you hire a cheap inexperienced inspector, the chances are that he will give you a cheap and inexperienced job of inspection. On the other hand, an experienced man will cost more money, but reliability is assured. If possible losses through poor inspection were weighed against the cost of the inspector, it would be found that in practically all cases the cost of inspection is much less.

One case reported illustrates this fact forcibly. The superintendent in charge of the construction of a large building was paid $200 per month. The inspector was paid less. Between them they managed to have a remarkable failure of forms, which cost the contractor thousands of dollars and

greatly delayed the work. Another instance might be cited, where a contractor was laying several thousand feet of concrete sidewalk. An inspector was hired who had had little experience on this work, though he claimed to have mixed a little concrete several years before. The result was that in less than six months the entire work crumbled away, and had to be made good at the expense of the city. Several thousand dollars were lost for the saving of possibly eighty. Incidents like these could be recounted by the hundreds, but it suffices to say that in general, such experiences as these prove that it pays to employ a high grade inspector on any job.


No inspector was on this job


Same materials, with
adequate inspection

Does Inspection Pay?

Fewer watchers and more thinkers among inspectors would result in a great increase in the effectiveness of their labors and an improvement in the quality of the work. A man who understands his work and knows intuitively when work is being done well, is worth many times the cost of one who merely counts sacks of cement and wheelbarrows of gravel. An ex-

perienced man senses trouble immediately on a job if it is present. This instinct comes to a person only through experience and training, and it costs good money to hire such men.

Characteristics of a Competent Inspector.

The inspector has a job which is not exactly pleasant at all times. He must control the work in the interests of good practice and a substantial compliance with the specifications. He must have a character and standing beyond reproach, and must believe in the right and in giving a square deal to all. Tact in an inspector will work wonders where bull-headedness will inevitably cause trouble. The ideal inspector is a man who has been trained in construction and engineering work, who has a judicial frame of mind, and who has some knowledge of human nature. These are seldom found in political job-seekers.

It sometimes happens that the engineer is free to select his own assistants and inspectors - in which case the rest of the problem is relatively simple. With competent men sufficiently paid, adequate inspection is assured, and satisfactory workmanship with good materials results.

All Materials Should Be Tested.

The testing of materials entering into the construction of public structures is a very important thing and should never be neglected. It is a part of the city engineer's duty to insist upon the use of first class materials, and upon the

testing of them all to insure that they comply with the specifications.

The engineer sometimes encounters public officials who do not believe in testing materials they use. "Looking at them" should suffice, in their opinion, and "the engineer who cannot tell good materials from bad ones by their looks is incompetent", they say. It is with such men as these that the engineer must deal, and it often proves a problem of no mean proportions to convince them of their error. Nevertheless, many instances of failure may be cited, where the lack of the expenditure of a few dollars for testing caused the loss of thousands of dollars in the subsequent deterioration or failure of the structure.

Such an instance is found in the work done some years ago on the improvement of University Avenue, Champaign, Illinois, from the Illinois Central Railway tracks to Wright Street, with a brick pavement. Owing to the inability of the contractor to obtain sufficient brick from reliable source to complete the entire job, he was permitted to use brick from another plant. The brick of known character were used from Wright Street to Fourth Street, while the others were used to complete the work, without tests being run on any material used. Within a year, the brick on the latter section began to show wear, and before five years had elapsed, the surface was in such rough condition that much money had to be spent replacing these defective brick in order to obtain a wearing surface able to withstand the traffic. This was a case where the ex-

penditure of $50 in testing would have saved this trouble and assured the use of good material on a $50,000 job.

Political Control of Engineering Operations.

The control, operation, or maintenance of public works after construction is often delegated to the city engineer as one of his duties, or is placed under his direct control and supervision. Here again enters the problem of securing competent men free from political control and experienced in the handling of such plants. The history of the gross mis-management of many of our municipal sewage treatment and disposal plants shows the ignorance of many public officials concerning the necessity for providing competent, well trained and experienced men as operators of such important safeguards of the public health. Municipal refuse disposal plants likewise can be made a success or failure, depending upon the character and ability of the men selected to operate them. It is the duty of the city engineer to insist upon the employment of properly qualified men for all work under his control.

Maintenance of Structures.

The maintenance of streets and bridges in the ordinary city usually is taken care of by the department of streets and alleys, which in some cities, as it properly should be, is under the direct supervision of the city engineer. Such work, and especially that of bridge repair, is essentially of

a highly technical engineering nature, and as such should at least be under the general control of the engineer. The work of sewer maintenance is usually vested in the plumbing or sewer inspector, whose organization is only too often an entirely separate and independent one. Storm water sewer maintenance, street maintenance and street cleaning go hand in hand, for upon the degree of cleanness of the streets depends the amount of dirt, leaves, sticks, etc., washed into the sewers with each rain, and upon this depends the number of stopped inlets, etc., not doing their duty. General control of all these things should be vested in one official, that cooperation may exist and that petty jealousies may be eliminated.

Legal Advice.

In nearly all cities under the aldermanic form of government, the city engineer is by law made a member of the Board of Local Improvements and usually becomes its secretary. In this capacity it is his duty to make complete plans and estimates for all special tax or assessment improvements and to keep the records of the entire proceedings. The law in this particular is very strict making it exceptionally difficult to obtain a legally correct record. The engineer, therefore, must take particular pains to obtain competent legal advice upon every step in the proceedings, that valuable time and effort may not be wasted in case a disgruntled objector seeks to cause trouble.

Types of Government.

The extent and character of the duties of the city engineer vary somewhat with the type of government in effect in the municipality, but the general duties and authority are much the same. In the aldermanic form of government, a superintendent of streets is provided for, but often this work is delegated to the city engineer. In the Commission form of government, one of the five commissioners is superintendent of streets and public works, having control over the streets, the engineef, and all works of engineering character.

In the City Manager form of government there is one executive, responsible for the successful and economical operation of the city, to whom the city engineer reports. The engineer in this case is often the head of the entire department of public works, which includes all work of engineering character, Regardless of the form of government, however, the city engineer is, next to the executive head of the city, the most important official, upon whom the responsibility is placed of directing the expenditure of many thousands of dollars. Upon his judgment depends the obtainment of good value for money expended, while upon his skill depends the safety and adequacy of the city's public works.

Illustrative of the widely varied and numerous duties and responsibilities that are sometimes entrusted to the city engineer, take the city of Sacramento, California, for an example, which is operating under the City Manager form

of government. In this city, the city engineer has charge of the following activities of the city government: the planning, opening, paving, maintaining and repairing of all streets, boulevards, alleys, and public ways; the construction and maintenance of all sewers and the sewerage system, the crematory and corporation yard; cleaning and sprinkling of streets; the upkeep of the levee system of the city; the operation of the city water works, filtration plant and water distributing system; the construction, maintenance and operation of all buildings, wharves, docks, chutes, ships, quays, and water front property; the construction and maintenance of fire, and police alarm systems; the supervision of automobile mechanics in the city's employ, and the enforcement of all rules and regulations pertaining thereto; the inspection of all electric wiring; the inspection of all buildings, checking of plans for new buildings, and issuing of permits for building erection or alteration; and the collection and disposal of all refuse. It is plain that here, the city engineer must be a man of wide experience, a good organizer and an executive of high caliber, having the similar qualifications to the general manager of a large corporation.

III. DESIGN AND CONSTRUCTION OF PUBLIC PROJECTS.

The engineer's problem in successfully handling the City's business lies not only in securing the confidence and good will of his associates, but also in the possession of sound engineering judgment, and the ability to so direct the work of his subordinates that the finished project will reflect great credit upon his organization and administration. Economy consistent with probable future requirements, both in design and construction, is very desirable and depends upon many features of the particular project which must be carefully considered, at the proper time.

Accurate Surveys Desirable.

The making of accurate and complete surveys forms the groundwork for the success or failure of all subsequent work. They form the basis upon which all estimates are made, upon which the designs are laid out, and upon which the final construction must depend. Great care should be taken to check their accuracy, and to assure correctness.

Topographic Map Invaluable.

The possession of an accurate large scale map of the city is very desirable, while a topographic map of the city and vicinity is of inestimable value. With these, it is not necessary to leave the office in order to design and estimate new pavements, sewers, water systems, etc., but instead, all necessary grades, distances and other measurements may be

taken directly from the maps, with surprising accuracy. With these, too, entire systems for future development may be planned and designed, so that in constructing extensions to pavements and sewers, the nature and location of all necessary underground structures will be known with certainty and provided for. The savings from these features alone would pay the cost of having such maps prepared for permanent record, yet it seems difficult for the lay mind to conceive their significance and value.

Vertical and Horizontal Controls.

The early establishment of an accurate system of vertical controls with permanent bench marks located at least at half mile intervals is very essential. It is the first step in the securing of a city-wide topographic map, and forms the means of establishing a definite city datum. Nearly all cities possess government geological survey bench marks bearing their elevation referred to mean sea level. These make ideal control points for the local surveys which are thus tied in with the work in the country surrounding.

The establishment of horizontal controls by triangulation also is quite desirable, but in the ordinary cities, unless a map of the entire city is being made, this is not essential.

Street or Sewer Surveys.

Surveys for street or sewer improvements, however, must be complete in all details, yet extreme accuracy in measurement is not warranted by the character of the work. Unavoidable errors in setting forms and placing concrete, together with the allowable variation in placing pavements in the street, do not usually warrant measurements being taken for horizontal layouts nearer than to the nearest estimated hundredth of a foot, while on the other hand, in exceptionally flat districts elevations to the nearest hundredth are essential. Corrections to measurements taken in ordinary city paving or sewer work for temperature and pull, and for curvature of the earth etc. are not necessary because construction operations do not permit or require the expenditure of time thus taken to secure such accuracy.

Bridge Surveys.

In bridge construction, however, different conditions govern, necessitating exact compensated readings at all times, so that measurements for design and construction purposes will not be subject to variation in different temperatures. In ordinary city work this will not often be encountered, but at times, especially in river cities, steel and reinforced concrete bridge construction must be undertaken. The city engineer, therefore, must be ready and able to handle such work when called upon.

Accuracy is required
in bridge building.

The making of borings, sinking of test pits, and the making of a general sub-surface survey along the site of the proposed structure is a necessity in the preparation of plans and estimates for bridge construction. Accuracy in this work means the saving of many dollars in foundation work, while mistakes may require the entire re-design of the structure.

1. DESIGN OF STREETS AND ALLEYS.

The designing of improved streets and alleys is one of the frequent and important duties of the city engineer. It is a problem which is only too often slighted or given little thought, and many of our streets show its results. We pave our streets to better transportation facilities, to improve sanitary conditions, and to beautify our city. We find requirements for paving in one district differing radically from those for another district while still a third section demands improvements unlike either of the others. Everything has its

place, so that there is no one best pavement, nor one best design, but instead each street in each district must be considered on its own merits, as to what its peculiar conditions require.

Classes of Streets.

We have in every city, therefore, several classes of streets, differentiated by the character of traffic, the volume of traffic, and the kind of district the pavement is to serve. These streets are classified also according to the character or weight of the traffic in the district served, giving us our primary or heavy traffic streets, upon which heavy trucking and teaming is done, including the through traffic streets, upon which our trunk highways pass thru the city; the secondary or medium traffic streets in which class falls our boulevards and principal through residence streets; and the tertiary or light traffic streets, which form the bulk of the cross streets and drives in our strictly residence areas. All of these classes of streets require pavements varying in character, according to the relative importance of cost, cleanliness, noiselessness, durability, appearance, slipperiness, tractive resistance and ease of cleaning and maintenance. It is the city engineer's problem, then, to weigh these various requirements and conditions in the selection of the type and character of pavements to be laid; to look into the future and foresee the effect of an improvement upon the quantity and character of traffic; and to base his decision upon the fair consideration of all the factors involved.

SUGGESTED LIST OF ITEMS TO BE CONSIDERED IN THE SELECTION OF PAVEMENTS, AND THE RELATIVE ORDER OF IMPORTANCE OF EACH FOR VARIOUS CLASSES OF DISTRICTS.

Order of Importance.	Office Building and Retail Stores District.	Wholesale Warehouse and Dock or Railroad District.	Boulevards & Expensive Residential District.	Medium and Cheaper Residential Districts.	Thru Traffic Thorofares All Districts.
1	Noiselessness	Durability	Appearance	Appearance	Durability
2	Appearance	Tractive Resistance	Durability	Cost	Tractive Resistance
3	Sanitariness	Ease of Maintenance	Sanitariness	Durability	Slipperiness
4	Durability	Slipperiness	Ease of Cleaning	Sanitariness	Appearance
5	Ease of Maintenance	Sanitariness	Noiselessness	Ease of Maintenance	Ease of Maintenance
6	Ease of Cleaning	Appearance	Slipperiness	Ease of Cleaning	Noiselessness
7	Slipperiness	Ease of Cleaning	Tractive Resistance	Noiselessness	Cost
8	Tractive Resistance	Noiselessness	Cost	Slipperiness	Sanitariness
9	Cost	Cost	Ease of Maintenance	Tractive Resistance	Ease of Cleaning

Primary Streets.

Pavements for primary streets must be designed to withstand severe and heavy concentrated loads. They must be of sufficient strength to carry heavily laden wagons or trucks of ten to fifteen tons capacity and must be provided with a wearing surface capable of resisting the destructive action of abrasion and impact caused by these vehicles. Streets of this character are commonly found on our trunk line highways as well as in the wholesale warehouse, railroad and dock districts.

Granite block, brick, sheet asphalt, wood block and concrete pavements are especially suitable for districts such as these. Durability, tractive resistance, ease of maintenance, and the degree of slipperiness are the points which should govern the engineer's decision, keeping in mind the fact that the construction, renewal and maintenance of a pavement on such streets makes necessary interruptions of traffic, thereby causing large losses at those times to business houses depending upon the use of the street for the continuance of their business.

The widths of these streets are necessarily determined by the peculiarities of the surrounding structures. In general, however, sufficient room must be provided for vehicles to back up to the curb for loading and unloading purposes, and also to give space for at least four lines of traffic, so that ample turning room will be provided for vehicles backed into

the curb, without blocking traffic from the opposite direction.

Durability should be the prime consideration in the selection of curbs and sidewalks for these districts. 6" x 24" Granite Curb is none too heavy for such work, while 6" should be a minimum thickness for concrete sidewalks in these areas. Here again, however, the judgment of the engineer must be called upon, and he must be prepared to advise in all these details.

Through Traffic Streets.

Through traffic thorofares in all districts must be paved to an ample width. Durability again is first on the list of requirements. Tractive resistance, slipperiness and appearance are also of importance, for higher speed characterizes the traffic on these streets, thereby increasing the collision hazard in direct proportion to the degree of slipperiness of the street. Brick, sheet asphalt, creosoted wood block and concrete are favorites for streets of this character.

Secondary Streets.

Pavements for secondary streets must be designed to withstand moderate traffic with occasional heavy loads. As these streets lie largely in residence districts, and serve as "feeders" to the main thorofares, appearance is usually one of the first considerations. The matter of maintenance, however, may have an important bearing upon the case, for the problem of the small city differs from that of the large one, in that the former cannot afford to keep up a fully equipped municipal

organization for maintenance and repair. Preference should be given, on this account, to a pavement which does not require a special maintenance organization, while freedom from need of repairs should be an outstanding characteristic. As a general principle, therefore, it may be stated that in a small community a more permanent and durable type of improvement is economically a sounder type to construct.

Width of Street a Variable

The width of street and width of pavement for secondary streets is dependent upon several conditions and may be considered from different points of view. One is from the viewpoint of appearance, governed by rules and proportion, or by making provision for predetermined widths of sidewalk strips and of lawn and parking spaces. Another viewpoint is that of traffic accomodation.

The first viewpoint applies principally to parkways, boulevards, and certain other classes of residence streets where beauty and proportion rather than economy and utility largely control the design. Making the roadway from 50 to 60 % of the street width between property lines will in many cases satisfy. The design of the planting strips and lawns will, however, nearly always control the width and arrangement of the paved roadways. Even here the expected traffic should receive consideration, but its subordination to other conditions may be perfectly logical and free from criticism.

Consideration of the roadway widths from the second viewpoint, that of traffic accomodation, obviously applies to the greater number of cases, and should prevail when considering any basis of design or the standardization of widths. Since there are various classes of traffic using the street, and since all classes have the common right to use the street, it should therefore be designed to afford each class the maximum of comfort and safety without abridging or destroying the rights of others. Here again is a problem, the satisfactory solution of which is up to the city engineer. There can be no general standardization of roadway or sidewalk widths, but instead the width of pavement should be an expression of the use of the street, or the needs of the traffic and the abutting property.

Economic Value of Width.

City pavements are expensive, and it is wise to carefully determine the adequate width. Since pavements cost from 50¢ to $1.00 per foot in width, for each lineal foot, or $2500 to $5000 per mile per foot in width, the maximum width should be the minimum to accomodate the needs of the traffic and the abutting property. Streets should not be paved so wide where use does not demand it.

Selection of Pavement Type Depends on Conditions.

Types of pavement suitable for secondary streets are many, and their selection depends upon the amount and character of the traffic expected. Brick, concrete, sheet

asphalt, bituminous concrete and bituminous macadam all have their places, and their selection should be left to the judgment of the engineer. Types of pavement most suitable for his consideration will depend largely upon the surrounding conditions and the cost. Topography affects to a large extent the selection of the type of construction. Upon steep grades, hard surfaced pavements such as brick, grouted stone block and concrete are generally used, the former usually being preferred. The minimum grade which may be called steep is about 6 or 8 %, while grades of 10 to 20 % or greater are found in a number of cities. For horsedrawn vehicles a rough surface with open joints was essential to afford a foothold. With motor vehicles, however, open joints are not necessary, but a surface affording sufficient grip for traction and braking, while avoiding slipperiness, is desirable. *

Stub-end streets, and streets receiving little traffic must also be given special consideration in design, for some pavements which give excellent service on well traveled ways, deteriorate rapidly when not exposed to the kneading action of traffic. This is a peculiarity of bituminous pavements which demands consideration. Hard surfaced pavements, therefore, must be given preference under these conditions.

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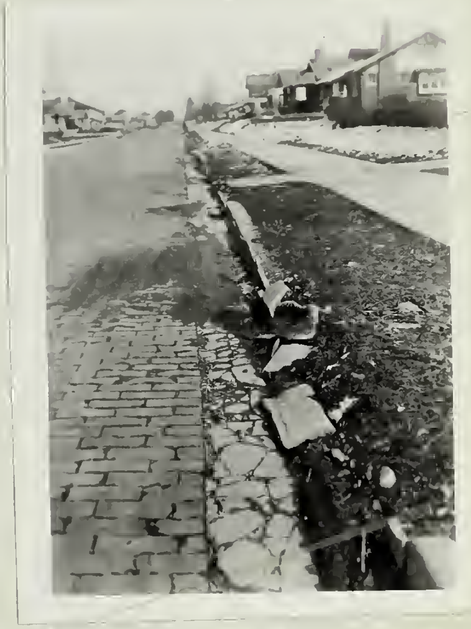
* For a further discussion of current practice in this regard, see Engineering News-Record, Vol. 81, No. 7, pages 323-324-325- August 15, 1918.

Stone curbing may become unsightly.

Integral curb is losing favor, due to construction difficulties.



"Skinning the job" will soon destroy the beauty of a street.

Combined curb and gutter is rapidly growing in popularity.

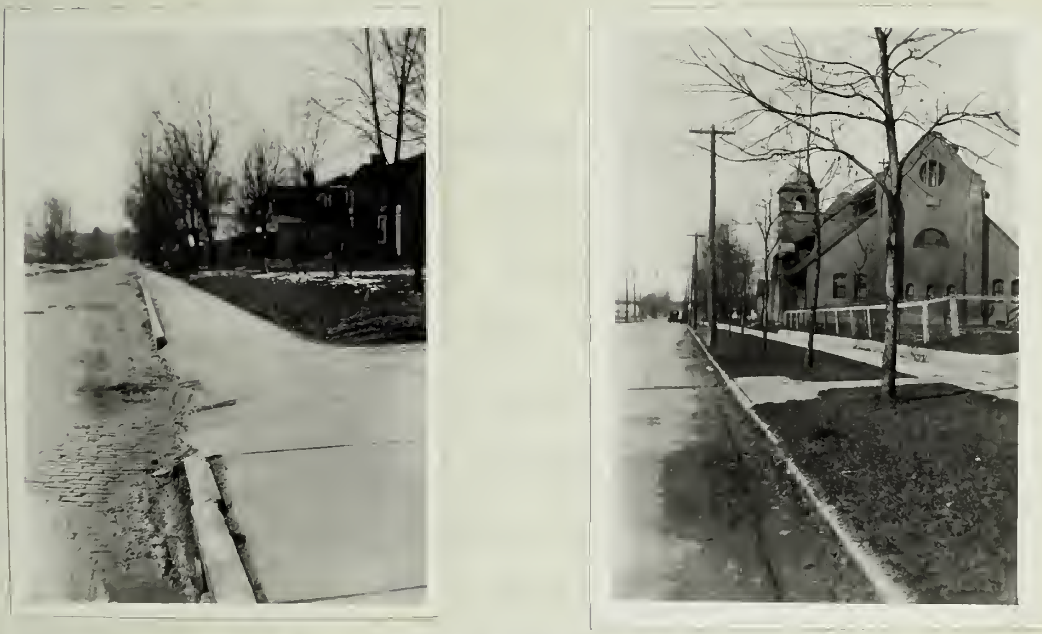
Curbs.

Types of curb used on various streets have been given much serious consideration during the past few years. Pavements have been laid with straight curb, both concrete and stone with integral concrete curb in case of concrete pavement, and concrete combined curb and gutter with pavements of all types. Preference is being given increasingly to the latter form for nearly all pavements for the reason that it is more sanitary and enhances the beauty of the street.

Sidewalks.

The location and character of sidewalks in residence districts is a problem worthy of special attention, for the location of a sidewalk can either enhance or destroy the natural beauty of the street. It can be an aid to public safety or it can be a source of continual danger to pedestrians. Many property owners unwittingly permanently mar the beauty and proportion of their street by placing their sidewalks directly adjacent to the curb. They also thereby introduce hazards to public safety in the private drives crossing such walks to get to the street roadway, for necessarily the sidewalk must be depressed to a great extent in order that the drive may slope properly to the roadway at the curb. This depressed space may cause serious accidents to pedestrians, and especially to strangers who may have to use the sidewalk at night. This hazard is greatly increased by snow and ice in cold weather. In most cities the city

engineer is expressly clothed with the authority to regulate the construction and placing of sidewalks, and it is his duty, therefore, to advise the citizens correctly in this matter.



Beauty and safety of streets may be enhanced or destroyed by the location of sidewalks.

Tertiary Streets.

The improvement of side streets and by roads, or "tertiary streets," is a problem for special consideration as to the character and placing of the paved roadway and sidewalks. These streets are of varied character: some are straight, yet narrow; some are curved and narrow; while others have various combinations of these and other characteristics. Dependent upon the probable density of traffic is the width of pavement and sidewalk. This is limited, of course by the width of the right of way. Of even more importance, however, is the

planning of the street and the control of trees and shrubbery along its sides, that the free view of traffic at least 200 feet ahead is not obstructed. This is very important from the traffic standpoint, and can often be easily taken care of if handled carefully.

Value of Abutting Property Important.

Many streets of this character are located in districts where property is of low value so that expensive pavements could not be laid. Cost is the important item to be considered. Here again the city engineer must exercise his ingenuity to find the most permanent form of pavement that can be considered. Sometimes local industries furnish free or at low cost, materials such as slag which with proper treatment can be converted into a reasonably good paving material. Local gravel pits often furnish material from which a good road may be built. Even the lowly cinder when properly handled, will produce a good road which with proper maintenance will last a surprisingly long time. It is evident, therefore, that expert attention must be given to these problems in order that adequate service may be had for the money available. It is the city engineer who is always called upon, and it is "up to him."

Alley Pavements.

In many cities, people are realizing more and more that alley pavements are almost as essential as street pavements. Many vehicles must use the alleys for delivery pur-

poses, while the automobile owner also has occasion to travel that way in getting to and from his garage, unless he is fortunate enough to own sufficient ground adjacent to his house on which he can build a private driveway to the pavement in front.

Two types of pavement have been universally used in alley work - asphalt filled brick, and concrete. Owing to the growing tendency toward the installment of public utility mains in alleys rather than streets, the brick pavement seems to be better suited to this use, for when excavations must be made, the brick can be removed, the concrete base cut through and replaced solidly, and the brick put back with asphalt filler, leaving no trace of the cut. In concrete, however, it is not so easy to do this, but still concrete is very popular because of its lower cost and its cleanliness. Drainage of alley pavements is effected by "dishing" or sloping the roadway slab toward the center, carrying all water down the alley to the sewers or gutters in intersecting streets or alleys.

Selection of Pavement Type Important.

The selection of the type of kind of pavement which shall be used on the various projects should not be left to the judgment of the property owner, for with him often the cost is the principal consideration. He usually comes to the public hearing with a few ideas about the kind of pavement he would like to have, but rarely is his notion based upon a definite knowledge of the qualifications which that pavement

should possess. He is, also, easily influenced by the one sided arguments of certain material promoters, so that in the course of a few days he may be prevailed upon to sign petitions for several different kinds of pavement, and in the end not know himself which one is really best.

This has happened a number of times in the writer's experience, nearly always ending in a general disagreement and legal battle in the courts, or a similar delay to the improvement by postponement. Such experience should convince the responsible authorities that the mind of the property owners is a fickle thing that cannot be given much latitude; that it is not gifted with the expert knowledge necessary to decide these things; and that it is easily swayed and stampeded by smooth-tongued orators for rival materials.

The greatest problem for the engineer, therefore, is to select the best type of pavement for the place, not costing more than the property is benefited, and then convince the property owners and other interested parties that his judgment is best. To do this requires the use of tact, diplomacy, persuasion, and argument, combined with a dignified personality to give the statements weight.

2. SEWER DESIGN.

Adequacy A Prime Consideration.

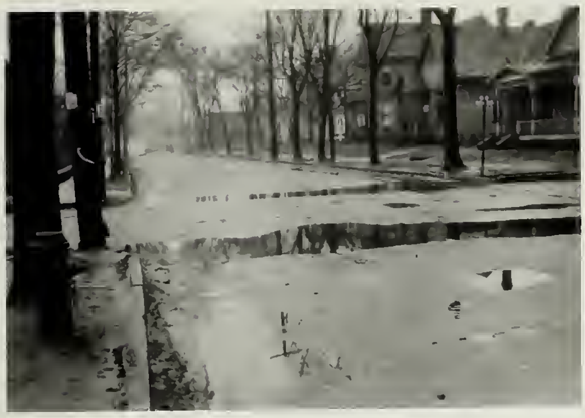
Sewers are designed and used for the removal of storm waters, for house sewage and industrial wastes, and for a combination of the above purposes. The city engineer, there-

fore, must consider in his computations whether or not it will be most economical to design for new or independent districts separate storm water drains and sanitary sewers, or combined sewers. In districts where some storm water sewers already exist he must design additional storm water drains to carry away excess surface waters, and sanitary sewers to permit the modernizing of homes. Many different conditions enter into his calculations and often several different locations present themselves for consideration - all of which are important in the final analysis of the problem.

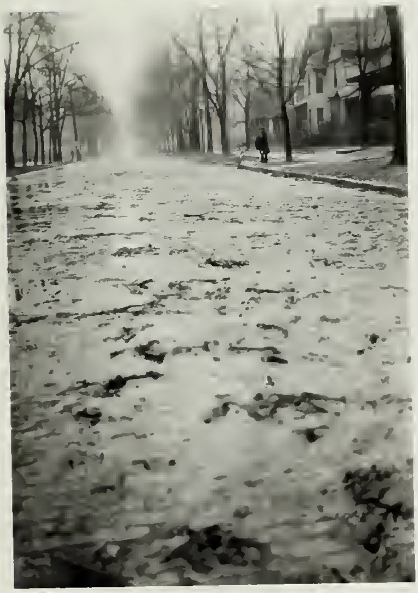
The sewer problem is one which causes the engineer to spend many hours in careful thought and computation, for the result of his labor must be a structure capable of protecting its district from overflow under all normal and most abnormal conditions. If he errs, he must err on the side of safety, for otherwise he will subject the city to damage suits resulting from overflow when the sewer is unable to handle the entire flow. He must not only consider present conditions in his calculations but also he must plan for future expansion and all possible changes of character of the district under consideration. In other words, he must design his sewers to be of adequate capacity for all probable loads.

Storm Water Sewers.

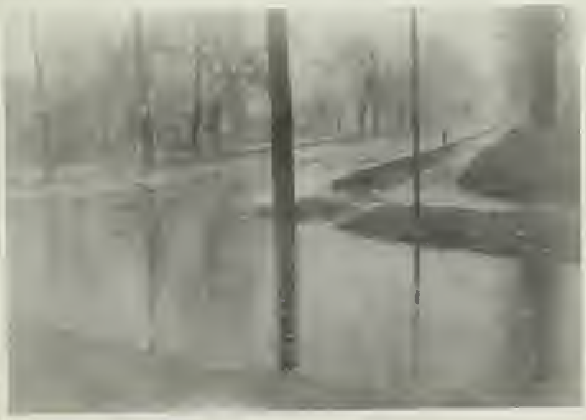
Storm water sewers must be of sufficient size to carry away immediately all water reaching them. They must be of such a size that they can handle not only the ordinary



Necessitates dangerous ditches across streets,



Causes deposit of debris on other streets, and



floods property in lower districts.

storms, but also the comparatively infrequent torrents occurring once every 10 to 20 years. Many formulas and diagrams, short cuts and time savers have been devised, all for the sole purpose of reducing labors in designing adequate sewers, and to enable the engineer to determine accurately the safe sizes of sewers to use.

Scouring Velocity Must Be Maintained

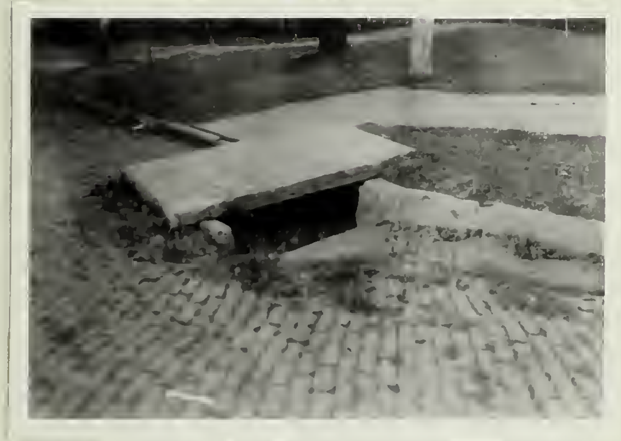
There are other considerations, however, which should always be in the engineer's mind in designing sewers, to eliminate future troubles in their maintenance. It is very desirable that the sewer be laid on such slopes that deposits will not be formed, and that the velocity of the water be sufficiently great to keep the sewer scoured clean and free from sand and other heavy debris. Sometimes this "fall" cannot be obtained, so that catch basins must be installed, designed to catch the sand, dirt and debris which would otherwise be carried by the water into the sewer.

Minimum Size Advisable.

If possible to prevent it, sewers less than 10" in diameter should never be used, for smaller sewers soon silt or sand up, and become inoperative when they are needed the most. This is especially true with inlet connections, for ninety percent of our sewer troubles are caused by too small sewer tile between the inlet and the sewer. Sticks, leaves, paper, and other debris get caught in the small pipe and a

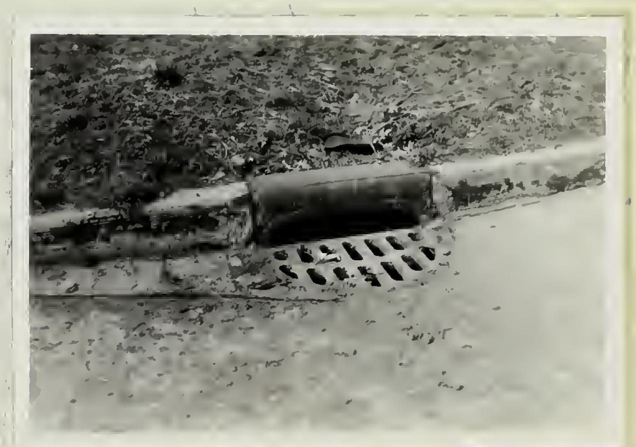
Inlets much utilize full capacity of outlet tile.

Effectiveness of storm water drains depends upon efficiency of inlets.



Effective, though dangerous to traffic and not in harmony with its surroundings.

Inlets must have adequate water ways, yet must harmonize with surroundings.



A few leaves and sticks effectively block the above waterway, rendering the inlet useless.

"stop up" is the result, often flooding entire districts before the obstruction can be removed.

Efficiency of Inlets.

The design and installation of inlets must be such that they will utilize the full capacity of the sewers without choking. They must also be built so that they may be easily rodded and cleaned, and otherwise kept in good condition. This is very important, for freedom from stoppage and ease of cleaning are much desired characteristics to be obtained in sewers.

Many experiments have been performed in St. Louis and elsewhere concerning the proper slope to [illegible], and dip into, the inlets on different grades with varying flows, so that a mass of interesting data has been collected. Much thought can be given to this problem, for altho apparently a minor matter, it really is of utmost importance. Many types of cast iron inlets are on the market which are practically worthless as far as effective service is concerned. Still other inlets are found in service that are very effective, but are dangerous from the standpoint of public safety. A satisfactory type of inlet can and has been developed for particular conditions, but there are many more inlets which are not giving satisfactory and adequate service demanding the engineer's attention.

Use of Manholes.

Many storm water drains have been laid for long distances with no means of access provided, so that in serious cases of stop-up the streets must be dug into in order to get relief. This is a condition for which engineers have often neglected to provide. Since the maintenance of sewers is an important matter, the proper structures must be installed when the sewer is built. Manholes placed not more than 300 feet apart, at all turns and at all points of intersection with other sewers are necessities and the means of maintaining adequate protection and service during the life of the sewer.

There are other uses to which manholes may be put, such as enabling the sewer to pass other sewers or obstructions without losing "fall." Many times in sewer construction, especially in towns where records have not been kept of the location of underground structures, pipes of various kinds will be encountered unexpectedly, preventing the further laying of the new sewer unless the obstructions are either moved or the sewer grade raised to go above them. Sometimes this raising eliminates one difficulty only to produce several more a little farther on. It is quicker and cheaper, therefore, to build a manhole around the obstructions, permitting the sewage to pass below and above it if necessary, and permitting inspection at any time.

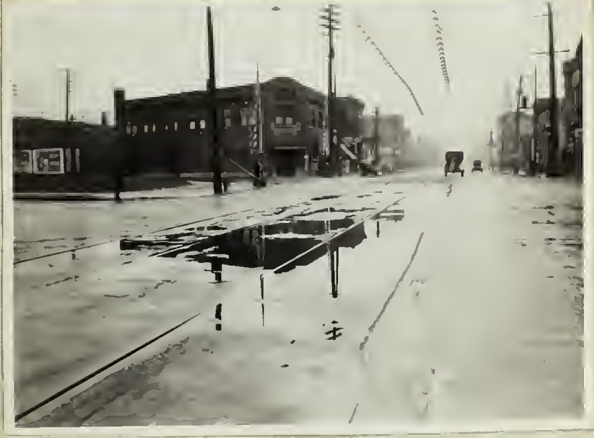
Lack of Future Planning of Sanitary Sewers Causes Waste.

It is a fact, however, that sanitary sewers are sometimes laid without consideration for future requirements, and that the lack of a definite plan often causes the overloading of some lines. Extensions arbitrarily determined are made also without regard to the capacity of the outlets, resulting in the overcrowding above mentioned. All of these evils would never be existent had a topographic map been available and a definite plan for sewerage been laid out.

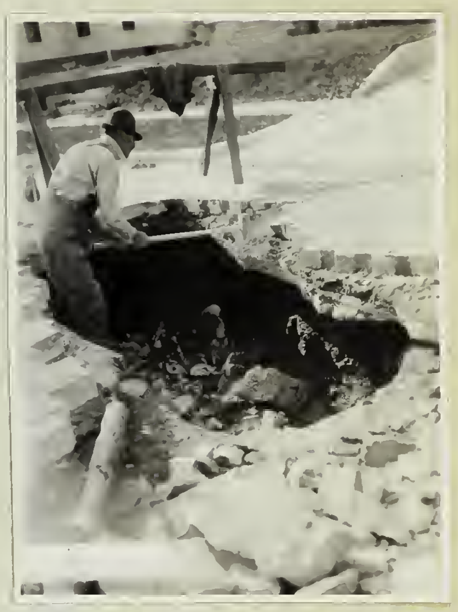
Small Tile Causes Damage.

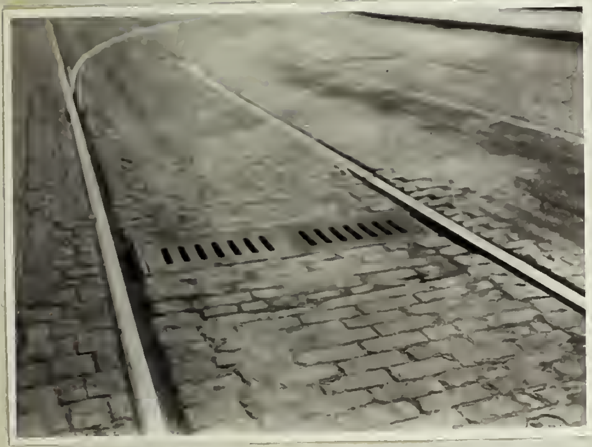
Many sewers have been laid with 6" tile and used for years. Some cities have little else in their residence districts. It is a fact, however, that where comparisons are possible, it has been found that trouble from stoppages has been much less where 8" sewers were used and in many cities, therefore, the 8" sewer is the minimum size permissible for all lines except house connections. The wisdom of this ruling has been made apparent to those who adopted it by the infrequent cases of trouble developing, and the consequent low loss from property damage caused by sewage "backing up into the basements." This saving in future service far offsets the little additional cost of the larger tile, and its use is appreciated by those who know the difference.

MISCELLANEOUS DRAINAGE PROBLEMS



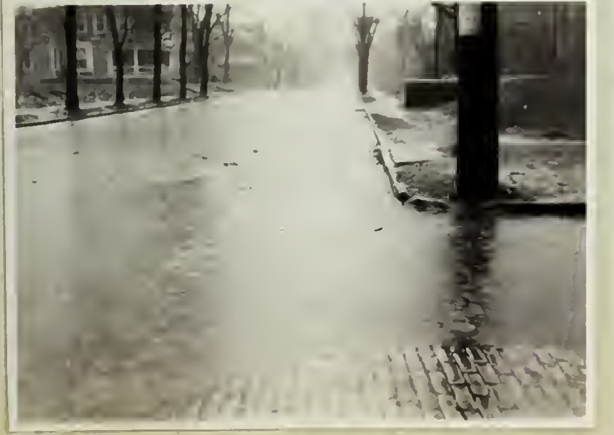
Street Railway Track Drain
Eliminates Standing Water.

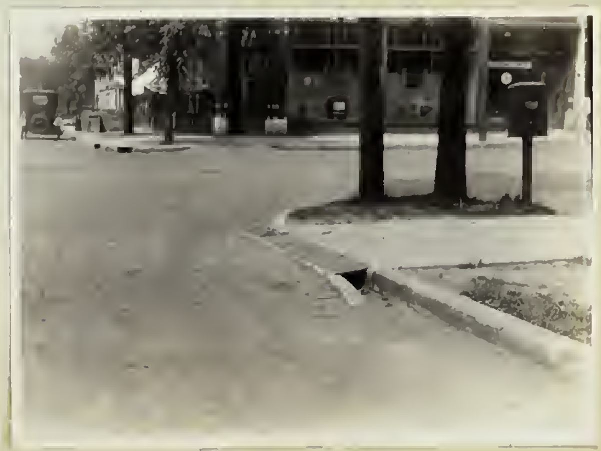




An Efficient Track Drain

Broken Sewer Causes
Dangerous Washout





An Inconvenience to Foot Traffic

Its Remedy

Unlawful Connections.

Sanitary sewers are never designed to carry storm waters, yet it is found occasionally that roof drains have been connected to them unlawfully. Penalties should be inflicted and the connections shut off wherever found, for such large flows as are introduced thereby are often the cause of many flooded basements lower down. One case comes to mind where an 8" extension to a 6" sewer had been made in years past. Roof drains and farm tiles had been unlawfully connected until every heavy rain caused such a flood down the sewer that basements were flooded, and manholes were filled. The head was so great that at one place the heavy manhole cover was lifted entirely from its resting place by the flow of water and kept in suspension for hours, while the diluted sewage flooded the street and ran off down the gutters. Such conditions are very apt to happen in cities when politics and inefficiency are permitted to gain the upper hand in engineering work.

Need for Manholes.

Manholes on sanitary sewers, as well as storm water drains are needed at intervals not greater than 300 feet in order that inspection and cleaning operations will not be hampered. Openings of adequate size must be provided, that the free passage of a fair sized man may not be hindered.

Flush Tanks.

Flush tanks at the upper terminus of all sewers are a general necessity, and when in operation, they serve to prevent deposits from accumulating. By the use of an automatic siphon a large volume of water is released suddenly at periodic intervals, forming a "wall of water" washing all deposits down the sewer. Properly designed flush tanks are so arranged that the sewer may be rodded or cleaned from the tank in case of serious stoppage.

Sewers must be laid with care.

Leaky Joints a Detriment.

Leaky joints in new sewers often cause trouble by permitting the liquids to escape into pervious strata, and thereby causing the solids to pile up in the sewer. Close inspection, therefore, is necessary at all times in the building of a new sewer, to assure the complete filling of all

joints with cement mortar, and to insure the proper caulking of all joints passing thru quicksand or gravel areas. Too much care in this particular cannot be used.

Need For Sewage Treatment.

Many cities are reaching the point where they must use some form of sewage treatment of their raw sewage in order that streams and lakes will not be polluted. States are exercising their regulatory powers in the name of health, and requiring in many cases that treatment plants be installed by cities at early dates. These requirements are sometimes thrust upon a city with little warning and a comparatively short time given in which to comply with the orders.

Design of Treatment Plants.

Sewage treatment plants are not playthings - they are not things which can be designed in a minute, and they are not of such character that "standard designs" can be handed out in a day's notice. Their satisfactory design calls for extended and detailed study of quantities as well as characters of sewage which may be expected today and tomorrow. Their action is not based on mechanics, but rather on bacteriology, and as bacteriologists, few city engineers are capable of qualifying as experts. Sewage treatment and disposal methods vary to great extents. Instead of the simple dumping of the sewage into rivers, depending for purification upon dilution and oxidation by the stream, we have the various processes of

screening and sedimentation, followed by different forms of treatment of the sediment or sludge in order to render it inoffensive; we have the various forms of tanks which depend upon bacterial action for their proper operation; and the several forms of filtration and irrigation processes, whereby the solids are first removed by filters and their appurtenances, and the liquids are disposed of by irrigation. We have also the activated sludge process for sewage treatment which has been developed in comparatively recent years and about which there is still much experimentation. From the foregoing, it can readily be seen that sewage treatment and disposal problems are not those which can be solved by the ordinary city engineer, but rather are those which require the consulting services of expert sanitary engineers to arrive at satisfactory and economical solutions.

Combined Sewers.

The use of the combined sanitary and storm water sewer is prevalent in many of our cities. Where built in times of low prices, its use is held in great favor and esteem. For new construction, however, unless exceptional conditions govern, it is often more expensive to build than the separate system, for its reserve capacity must necessarily be large, and the entire large sewer must be placed deeper to handle all house drains. Here again, however, it is the duty of the engineer to prepare comparative cost estimates on the new work, that it may be proved which is the logical

[illegible]

[illegible]

[illegible]

one to install.

Sewage disposal in cities having combined types of sewers, is often by dilution, altho where treatment has been required, regulators may be installed which will cut off storm flow from dry weather channels and thus not overload or damage the treatment plants.

Design of Combined Sewers.

The design of the combined sewers is one which requires intensive study and investigation concerning the relative quantities of dry weather and storm flow. It requires the careful proportionment and shaping of the sewer invert to carry these flows without the slopping or overflow of the dry weather channel and it requires the assurance that the heaviest storm on record will be handled with ease, and without overflow. Necessarily, therefore, combined sewers must be made of greater capacity and deeper than the separate system, for with the ever present danger of overflow, and backing up into basements, the engineer cannot afford to take chances, while an occasional overflow or flooding of the pavement in excessive rains may be permitted with the separate system.

It is plain, therefore, that the design and control of sewerage systems cannot be entrusted to a novice, but instead, the city engineer must be possessed of sufficient knowledge of this work that he can design the ordinary sewers economically. He must be able, also, to secure expert advice

on the more detailed problems presenting themselves, that the taxpayers' money may be not wasted.

3. BRIDGE DESIGN.

The design of bridges, also under the supervision of the city engineer, is a problem which requires careful study and often expert advice. It is a task which is strictly technical, and one which calls for the use of good common sense and judgment in the study of the various characteristics of proposed structures and the selection of the best layout and plan. It is an opportunity for distinctive service which every engineer should enjoy, for it enables him to exercise his imagination, to employ his creative genius and to test out his good judgment, taste and discretion in the various questions which continually arise on work of this character.

Preliminary Surveys

To obtain the preliminary information necessary for an economical bridge design, the engineer must first secure all available data concerning the proposed site. He must make accurate topographic surveys of the bridge site and its surroundings. He must obtain a general survey of the total watershed of the stream to be bridged, that the total area, the character of the land, its vegetation, and its slope may be determined. Careful borings at frequent intervals must be made along the entire bridge site, and test pits sunk at strategic points to check the accuracy of the borings and to

obtain all possible information concerning the character of the strata and the depth to the probable foundation. The high water level is also an important item, though often one hard to ascertain. All of these things the engineer must know before he can proceed intelligently with his studies.

Accuracy Demanded.

His surveys for the proposed structure must be taken with accuracy, for an error of less than an inch may prove a vital matter. Reduction of all tape readings to standard pull, compensated for temperature and other possible errors is an essential matter, for in a structure of any great length, calculated and actual measurements must agree exactly, else serious difficulty may occur in the layout and construction. All possible information pertinent to the district and available sites must be at hand, that the engineer, with his power of vision and creative imagination may form a mental picture of the problem and its several possible solutions.

Determination of Type.

In order to produce an economical design, the engineer must determine the type of bridge most desired, and the one most suitable to the location. He must ascertain the maximum standard loading, both live and uniform for structures of the character proposed, and the factor for impact which his judgment may dictate. He must decide on the desired width of roadway and of sidewalk, and upon the type of pavement to be

used. All of these matters are of importance, and must be settled before a design of any detail can be made.

Considerations in Design.

With the foregoing information at hand, the engineer can make various layouts, using uniform and non-uniform span lengths, and various combinations of spans, estimating each for the purpose of determining the most economical combination. Sometimes in long bridges, series of uniform span lengths are more economical because steel arch centering and forms may be made up and used repeatedly, instead of intricately braced wooden forms and centering. Other conditions may be introduced, though, which will prove of greater importance and require a different layout to be used.

As a general principle, however, the bridge should be designed so that the various members require the minimum of material consistent with safety and strength. If made of concrete, the engineer must always keep in mind the question of whether or not the structure as designed is easily formed - whether or not the forms required have sufficient inherent strength to resist bending, warping or springing out of shape, and whether they can be made with little waste of lumber. Structures permitting the repeated use of forms, or permitting the pre-construction of forms in the shop, oftentimes prove the most economical and quickest to build. Anything that will permit the saving of time and material on forms for reinforced concrete work, will prove of great value in the saving of money.

The cost of bracing and forms constitutes a large part of the cost of concrete structures.

Services of Consulting Engineer Needed.

In designing and constructing a bridge of any magnitude, it is customary and wise to retain competent consulting bridge engineers to design the structure and inspect its construction. It is very desirable, unless the city is large enough to support a bridge department, to have their services extended to include the complete control of all building operations pertaining to the bridge. This feature is one which has proved of great value in securing first-class workmanship and a good structure. It insures the elimination of inefficient inspectors, and secures the employment of well trained engineers for engineering work, a thing which is oftentimes difficult to do, owing to interfering political patronage.

IV. MAINTENANCE OF PUBLIC WORKS.

1. STREET MAINTENANCE.

The maintenance of streets, sewers, bridges, and other public property is one of the most important duties of the city government, and should be always under the direction of the city engineer. Such work is essentially of an engineering nature, and as such it should not be placed under the control of a non-technical politician whose only asset is that he is a "good fellow." Sad to relate, this situation is only too often true, so that we sometimes find former "druggists", saloonkeepers, confidence men and merchants of various sorts appointed as superintendent of streets, sewers, or bridges, who usually draw their pay and hire a foreman to do their work for them. Happily, however, this state of affairs is gradually disappearing, and people are realizing the value of adequate technical supervision of the expenditure of their money.

Maintenance of Streets.

Aside from new work, the proper and economical maintenance of streets and alleys forms a good portion of the city engineer's problem. In some cities this work is entrusted to a superintendent of streets, but in many of the more efficient municipal governments, this work is directed by the city engineer, resulting in the material improvement of the city's streets.

The judicious use of a road grader
will work wonders with earth streets.

Earth Streets Demand Attention.

The maintenance of earth or unimproved streets and alleys constitutes the city's greatest liability, yet the earth streets are usually the most neglected of city highways. Although there are often more miles of earth streets in small cities and towns than there are pavements, it is generally found that very little attention is given to keeping them in passable shape. The cause of this neglect is usually not an unwillingness on the part of the public officials to do the work, but rather an ignorance of how best to do it in order to make the available money secure the most permanent results. This is where the city engineer can devote his energies to good purpose.

To properly care for an earth road does not require great skill, but rather calls for the exercising of common sense in the use of the proper tools. Adequate, rapid and

Adequate, rapid and thorough drainage is essential to good roads.

thorough drainage is the prime requisite for good roads, and is of especial importance to city streets. In order that water may drain quickly from the street to the gutters, the street surface must be kept reasonably free from ruts, holes, sags, etc. by the proper use of road maintaining tools. The grader, drag, road maintainer, etc. all have their particular uses on the road.

The road grader is employed to shape up the roadway to an even, slightly crowned surface - not to the steepsided "hogs backs" which are found so often. A slope of 1/2 inch to the foot is plenty, and it should never exceed twice that amount. Much good can be accomplished with this tool in experienced hands, and yet, more damage can be done by a novice in an hour than can be repaired in a week.

The road drag is the companion tool to the grader, and is the means of keeping many of our dirt roads in excellent condition at little expense. Ruts cut in the road in wet weather are smoothed over by the drag, producing a smooth

compacted surface for travel.

A very efficient patrol maintenance organization may be developed by the engineer, keeping the street in excellent condition most of the year, at a comparatively small expense.

Surface Treatments.

When this is accomplished, the use of a surface application such as asphaltic road oil is a great aid to the retention of smooth roads. A good grade of oil applied when the road is in proper condition serves as a waterproofing and a binder. Money is often wasted by the application of road oil at the wrong time, and a great injury done to the road surface as well. Oil should be applied in the spring or fall, or both, after the road has been properly shaped and dragged and before the dust has begun to form. If this is done, the street may be expected to shed water quickly and remain smooth throughout the season. Oil applied over ruts or deep dust does not accomplish the results that are normally expected of it, and money is thus often wasted.

Freezing and Thawing.

Intermittent freezing and thawing of the roadbed during the winter and spring months frequently takes the "bottom" out of the road, and destroys the oiled surface. Oiling, therefore, must ordinarily be done over each year, preceded by the usual grading or dragging of the street to secure a smooth surface.

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All of the foregoing, however, cannot prevent earth streets from becoming impassable at certain times during the year. Rains, freezing and thawing, excess water in the soil, and inadequate drainage sometimes combine to make the best of earth roads or streets seemingly have no bottom, but constant and careful attention, supervised by the city engineer, will prove worth while.

Maintenance of Pavements.

The maintenance of street pavements, as well as earth roads, calls for the use of great care, good judgment, and skill. Attention is required because of the formation of chuck holes or breaks due to the general wear of traffic, by the opening of pavements for connections or repairs to underground pipes or cables, and by the damage from poorly constructed and maintained street car tracks.

Methods of repair of pavements made necessary by general wear, vary with the type of pavement used. The city engineer's advice in this matter is often the means of saving many dollars, and it is a part of his problem, therefore, to endeavor to have his ideas put into effect.

Repairs to Bituminous Pavements.

The surface of bituminous pavements can be kept in good shape by the frequent use of surface treatments, using either a thin asphaltic product or a coal tar product, applied under pressure by tank wagons or trucks after all holes or

Breaks are repaired with cold-mixed bituminous concrete as shown, or by penetration method.

Cold application bituminous seal coat can be applied by hand or by tank wagon.

The surface is sanded immediately and opened to traffic the next day.

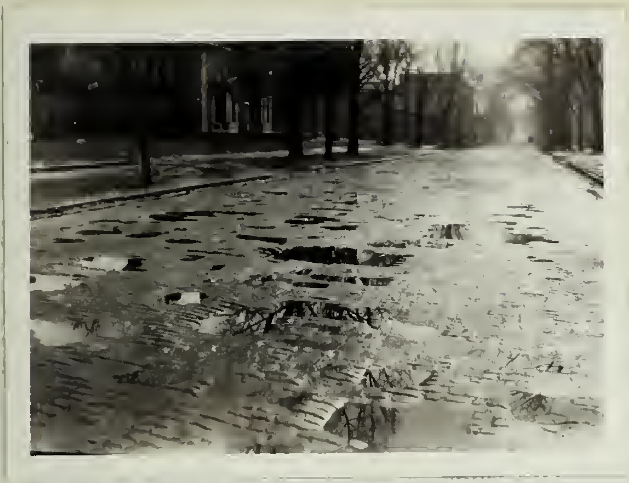
breaks in the pavement have been repaired. Such treatment, using paint coat application of from 1/4 to 1/2 gallon per square yard covered lightly with pea gravel or stone chips, usually puts these pavements in shape so that they are able to withstand traffic for several years longer without additional care.

Brick Pavements Require Little Attention.

Brick pavements require different treatment - either in the replacement of a few bricks here and there, the tops of which have been crushed off as a result of improper penetration of cement grout filler and the subsequent expansion due to increase of temperature, or the replacement of worn down patches of soft brick in our older pavements. The brick pavement, however, is the most foolproof pavement in city use, and its maintenance troubles are a minimum.

Resurfacing Worn Pavements.

Times come, however, with brick as well as with other hard surfaced pavements, that the wear of traffic makes the laying of a new wearing surface imperative. Here again is a part of the city engineer's problem, in advising what methods to employ and what materials to use in this work. Much has been said of resurfacing old brick pavements with asphalt or tar mixtures, but where paving brick may be had for a reasonable price and where the foundation is adequate, the old brick pavements may be resurfaced by the removal of



After thirty years service.

Worn Pavements
Require Attention
New surfaces are
easily applied.

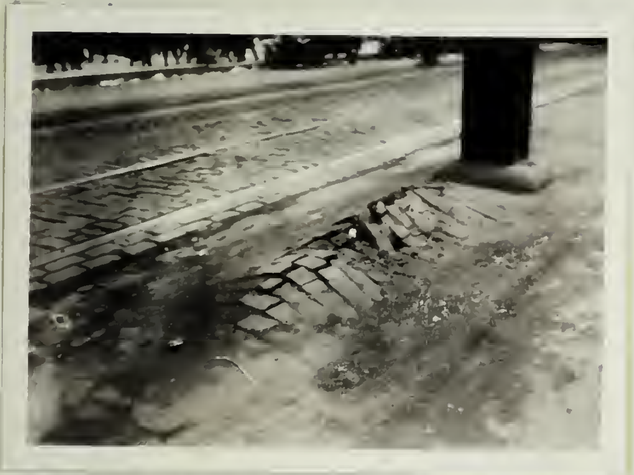
New brick surfaces form
foolproof pavements.

With adequate foundations,
New surfaces can be laid
at low cost.

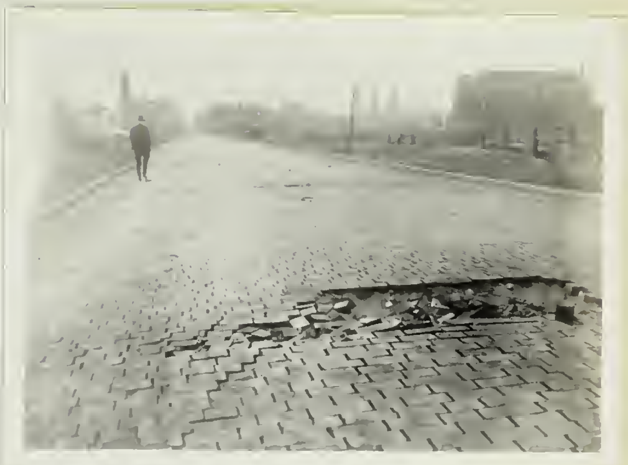
Sheet asphalt produces
smooth, beautiful streets.

the old brick and the laying of a new asphalt filled brick pavement at a cost which will not greatly exceed that of the bituminous surfacing, and will furnish a wearing surface much more foolproof and longer lived.

In cities where asphaltic pavements are the rule, rather than the exception, this may not be exactly true on account of the cheapness of the asphaltic material and the availability of experienced repairmen. In many of our smaller cities, however, where the mileage of brick streets constitutes the greater proportion of the entire mileage of paved streets, the cost of bituminous surface is somewhat higher because all materials, the plant to mix them, and the experienced workmen must be shipped in to handle the work.



When sand cushions are used,
the entire surface often is
heaved in this manner



Improperly treated blocks
sometimes shrink, and float
away in heavy rains.

Wood Block Streets Constitute Special Problem.

Wood block pavements present problems in maintenance oftentimes difficult of solution. Shrinkage of the blocks

sometimes seriously endangers the permanence of the pavement permitting the surfacing to float away in times of heavy rain, while expansion troubles heave the surface into irregularly humped spaces, and render it dangerous for traffic. All of these conditions call for different remedies, some of which are still in the experimental stage.

Old Trenches Cause Much Damage.

The greatest source of uneven surfaces in the small cities, however, has been improperly backfilled trenches under the pavements. On this account, municipal control of the replacement of pavements over openings made in the streets has become absolutely necessary. More trouble has been experienced, and more pavements have been ruined from this cause than from any other. In times past, before municipal control, anyone could make openings in pavements, throw back the dirt without tamping, pile the broken concrete on top of that, and relay the wearing surface. Such shoddy work, of course, could only result in the settlement of the trench, and the formation of a very dangerous hole in the pavement. The replacement of such sunken portions of pavement forms a large part of the pavement repair bill of our ordinary cities.

Municipal Control of Replacement Necessary.

Under municipal control, and under the supervision of the city engineer, such poor work is eliminated. Earth is tamped solidly back in trenches, and to prevent any settlement

Replacement of Pavements

Must be under municipal control.

from affecting the pavement surface, a plain concrete foundation slab 12 inches thick and extending 12 inches on solid ground on each side of the old trench is laid, upon which the wearing surface is placed. Settlement taking place thereafter is prevented from affecting the surface of this slab which bridges the trench. Such work has been carried on under the writer's direction and in three years, not one pavement so treated has sunken over excavated places. The actual cost plus 10 per cent has been charged to property owners for the work, thus relieving the city from the expense of such replacements.

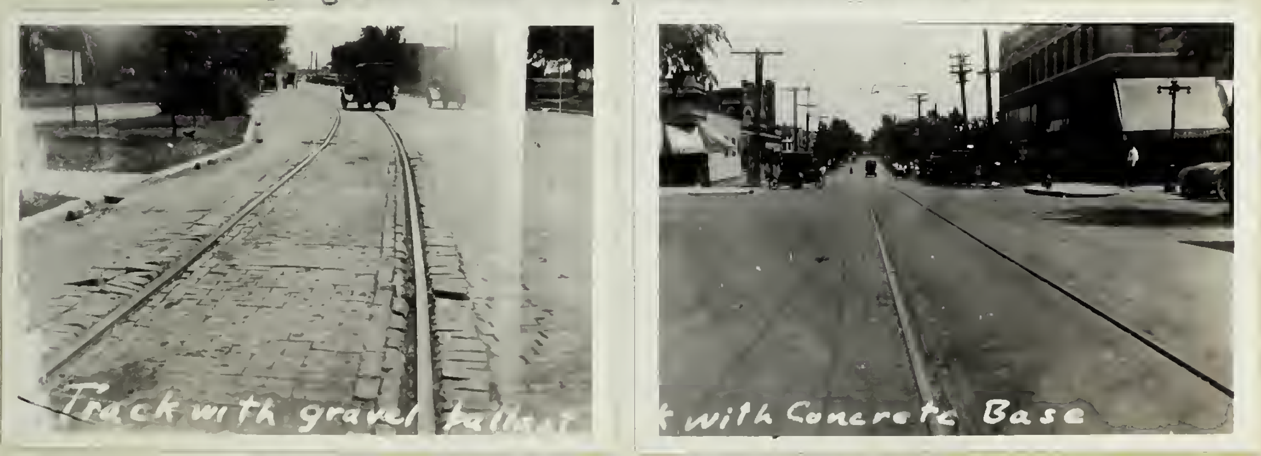
Unstable car tracks
damage many pavements.

Car Track Troubles.

Much expense can be saved in future repairs to pavements if they are constructed according to best practice, with all possible preventive measures taken. On streets containing

Curbing along car tracks.

Of great value to pavement maintenance



Substantial track construction pays good dividends.

street railway tracks, considerable damage is done to pavements several feet adjacent to the track structure by the wave motion of the tracks under every passing car. This motion is greatest with stone or gravel ballast, and it is with this type of track structure that the most pronounced destruction of pavement is found.

Sub-Curb or Header Curb Has Definite Use.

Under most railway franchises, the maintenance of the pavement between and for one foot adjacent to the railway tracks is done by the street railway companies. Damage to the pavement by unstable track structures, however, often extends several feet to the side, thus ruining pavement paid for by the taxpayers. It is the city engineer's problem, therefore, to endeavor to secure substantial track construction, and in new work, to protect the city's pavement against damage by the track. This has been done in a few cities by the use of the sub-curb or header curb, either of concrete, a combination of concrete with a steel angle paving guard, granite curb or wood blocks made for the purpose.

In all designs, this curb runs parallel to the track, at the outer limit of the traction company's right-of-way, separating the city's pavement completely from that in the track space.

Advantages of Curb.

The sub-curb or header curb has many advantages. It affords ample protection from poor track work and from the lesser movement of well constructed track. It confines all pavement damage to the point of its origin. It allows tracks to be repaired, taken up and relaid without damaging the abutting pavement, and forms a paving line for all new work. Its expense is not great when the benefits to be gained are considered, and it should be the aim of every engineer to install it wherever possible.

Other Phases of Pavement Maintenance.

There are many other phases of the city engineer's problem relative to pavements which are impossible of discussion here. There is the problem of adequate financing of pavement maintenance, of substantial construction of that portion of the pavement lying between and along the tracks at railway grade crossings and the proper maintenance of such crossings after construction. These and many others form a real problem for the city engineer to solve, and require thought and good judgment.

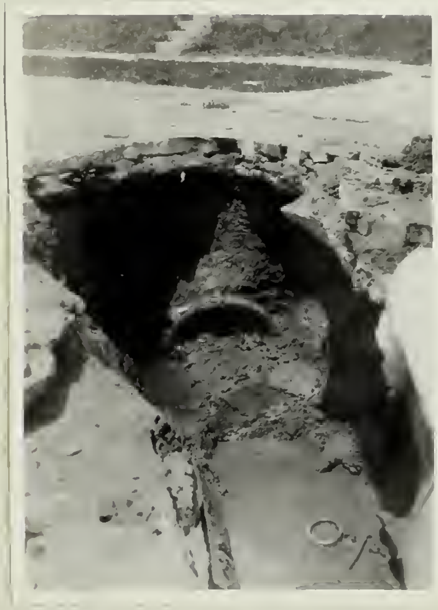
2. SEWER MAINTENANCE.

The maintenance of sewers in the small city is a problem of less extent, but of no lesser importance than that of pavements. Altho unseen, sewers must function continually, else great damage may be caused to all structures above ground

by storm waters, and to homes by the "backing up" of the sanitary sewers into basements. Eternal vigilance is the price of safety, and this applies to sewers at all times.

Sanitary Sewers Require Continuous Maintenance.

Unless a sanitary sewer system is composed largely of 6 inch pipe, its maintenance is usually simple. Constant inspection and readiness for immediate service in case of stoppage, however, is needed to keep property damage to a minimum. Few people realize the necessity for keeping rags and debris of any size from the sewers. Towels, rags of all kinds, garbage, etc. have been found in sewers upon investigation of cases of stoppage, and it is the duty of the engineer to see that his sewers are designed so as to afford the least opportunity for such stoppage to occur.



Sewers sometimes break down, greatly decreasing the effective waterway. A hole 5 feet in diameter was washed out under this pavement before discovery.

Occasional Cleaning Advisable.

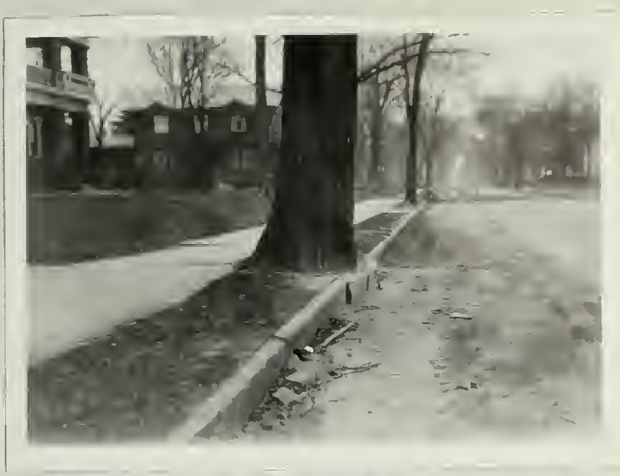
Sanitary sewers must be cleaned periodically, that the full tile may be available for service at all times. They must be cleaned to remove root growths, and also sticks, stones, rags, garbage, etc. which people thoughtlessly throw into their toilets. Occasionally, too, sewer pipes break down, reducing enormously the effective area of flow in the sewer. These failures are soon found by the cleaning machine, though, and must be repaired. The use of one of the standard sewer cleaning machines will go far toward securing unbroken service and a minimum of stop-ups in sewers of this character, and its value in such service can hardly be estimated.

Occasional inspection of flush tanks is needed, that the proper flow of water be maintained. Many times water companies in periods of drouth, shut off the flow of water in flush tanks and fail to turn it on again, charging the city for the service, however, all the time. Any such negligence will soon be detected if a system of regular and continuous inspection is in force.

Replacement Work Needed.

An additional problem in the maintenance of old sewers, is the replacement of old inspection tubes and lamp holes with standard sized manholes, to enable direct inspection and rodding to be done. It was the practice in years past to install these things instead of manholes, as money savers. They have not lived up to their reputation, how-

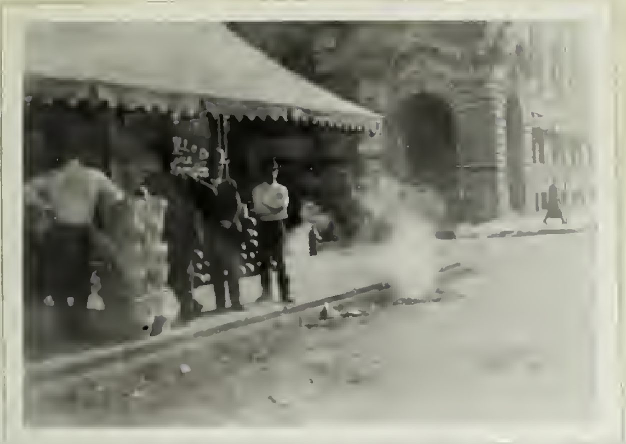
ever, and have caused more trouble by settlement and breakage than their worth.



Sidewalks, pavements and curbs are heaved out of line by tree roots.

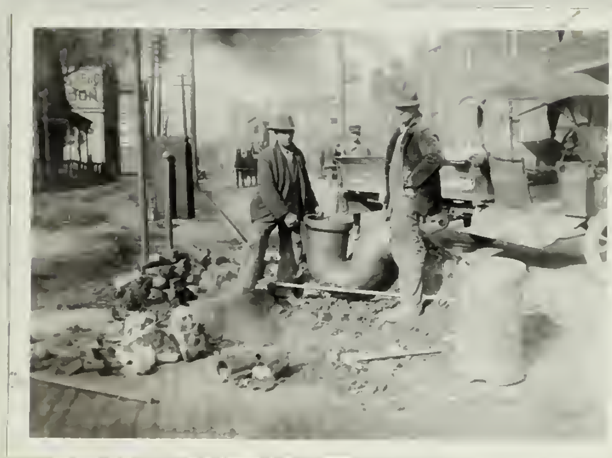
Removal of Damaging Trees Imperative.

The city engineer can do a great service to the community and incidentally to the sanitary sewers, in the securing of legislation compelling the removal of the Caroline Poplar tree from the city streets. With this should go the cottonwood, the willow, and the soft maple, for the roots of these trees spread out toward water, and often travel many feet to a sewer. Finding a tiny crack, they penetrate and grow into large masses of tangled roots which eventually clog up the sewer. They cause great damage to sidewalks and pavements too, by their large roots extending along near the surface of the ground heaving the sidewalks and pavements without mercy. Their removal and replacement with harmless, more beautiful and permanent hardwood trees would be a great benefit to the community.



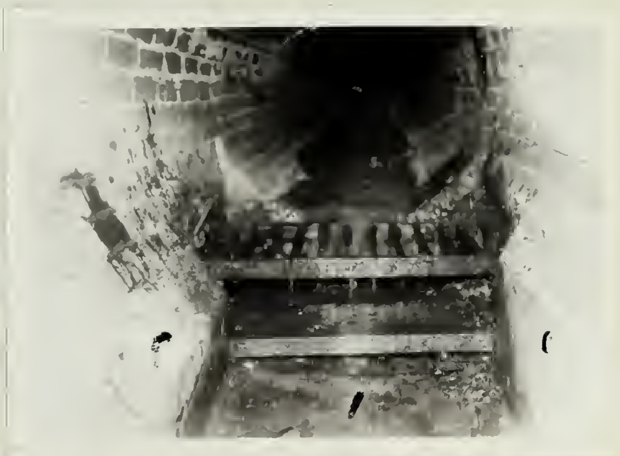
Foul smelling vapor renders store almost untenable.

Industrial Wastes in Storm Water sewer cause the emanation of an asphyxiating stench from inlets. Creamery's sour cream, brewery's bad brews, and laundry's hot water wastes cook up fearful odors.



All inlets affected were trapped.

A leaping weir, installed in the sewer near its outlet into a small creek, dropped the foul-smelling sewage into the main sanitary sewer which passed below.



Leaping weir drops dry weather flow into main sanitary sewer.

Maintenance of Storm Water Drains.

Storm water sewers, however, need not be troubled with much growths. They are larger, and have only intermittent flows, which do not encourage root growths. The maintenance of storm water sewers, therefore, consists largely in

Obstructions must be removed by rodding.

Stopped up drains often cause flooding of large areas.

the removal of stoppages caused by sticks, leaves, paper, etc. becoming caught in storm water inlets or in their connections to the sewers. Such connections less than 10" in diameter cause much trouble of this character, and should never be installed. These stopups cannot always be prevented. Gratings can be put over the sewer openings, only to be clogged in a short time with leaves or paper plastered across the openings. In most sewers, therefore, except those on flat grades, open inlets are to be preferred and frequent inspection practiced, that such cases be remedied as soon as found.

Catch basins, installed to remove dirt and debris from the waters before entering the sewers, require cleaning after every rain in order to make them serve their purpose. This is seldom done, however. They are forgotten - dirt, manure, and other street filth lies there wet and decays, causing odors and forming breeding places for flies and germs. It is better, therefore, that catch basins be eliminated from the sewers in all possible cases, and particular attention be given to those in use that a nuisance be prevented.

Combined Sewers.

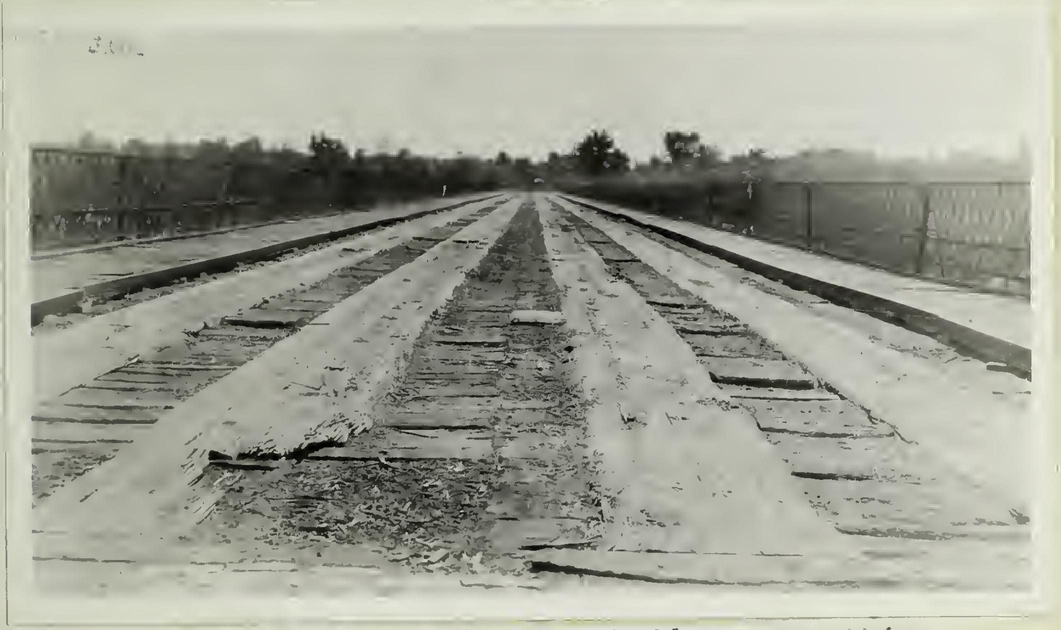
Combined sewer systems obviously are little troubled with maintenance problems, except on the short feeder sewers which are of small sized tile. Although the first cost is often greater, the upkeep is little, so that many prefer it to any other.

Sewer Maintenance Should be Continuous.

Sewer maintenance is essentially a continuous maintenance. It consists of constant inspection for preventive purposes, and a constant readiness for action, similar to that of a fire department, ready to answer alarms of stoppage quickly, that property may not be damaged and that the public health may be preserved.

3. MAINTENANCE OF BRIDGES.

Bridges are built - then forgotten - until they fall down, rusted through, or until a wagon or truck goes through the floor possibly causing the loss of life. Few officials give their bridges a thought as to whether or not they should be painted or floored or whether they might need bracing or strengthening occasionally, to better enable them to carry the ever increasing loads that are being carried over our highways. The fact that the structures are still standing and carrying traffic is sufficient evidence, in their minds, that attention is not needed. It is the city engineer's duty, therefore, to endeavor to convince these men of the seriousness of the situation - to show them the damage and waste caused by the rusting of steel structures, and by the rotting of timber floors when not properly taken care of.



Impact stresses from such floors as this severely tax the strength of bridges.

Steel Bridges Should Be Kept Painted.

Many of our steel highway bridges would be giving service today had they been painted at the proper time. Rust should never be allowed to gain a foothold, for when once started, it cannot be removed without the application of much elbow grease and steel wire brushes, or the use of the sand blast. After being thoroughly cleaned, the use of red lead and oil as a first or priming coat of paint is to be highly commended, for besides being an excellent preserving medium, its color shows immediately any spots which have not been reached. Its value in this particular is not to be despised, for it, likewise, indicates plainly any spots which have not been covered with the second coat of paint. This second coat, which should be of a standard grade of graphite paint, should be applied in the same manner as the first coat, and thoroughly brushed out to fill and cover all rust pits, cracks, etc. and all corners difficult to reach. Two coats of paint usually suffices for the protection of our bridges, and should be renewed at periods before rusting has again set in.

Bridge Floors Must Be Kept Safe.

Many of our bridge floors are really in dangerous condition from rotting, both wet and dry. Timber floord bridges on earth roads are often found covered with mud several inches deep, keeping the wood almost continually damp. Nothing could produce more ideal conditions for decay than this, for the dampness promotes fungus growths which

attack the wood and soon render it incapable of carrying the required loads.

White and burr oak lumber form excellent material for bridge floors, where creosoted pine timbers cannot be used. Care must be taken, however, to avoid red oak or its kindred species, for these timbers are peculiarly susceptible to rot, and will give poor service unless kept well dried out. Material 2 1/2 to 3 1/2 and 4 inches thick is most frequently used for timber floors, while 1 1/2 to 2 - inch material is sufficient for sidewalks. Sound square-edged timbers, true to size, and free from wind shakes, large knots or other imperfections should always be demanded.

Three inch creosoted wood block surfaces laid upon 4-inch creosoted plank floors are much to be preferred, however, for although the first cost is more, the life is almost indefinite, thus making the cost per year much lower. It is often difficult to convince the "powers that be" of this economy, for their eyes are glued to the first cost, and they cannot comprehend any saving in longer life. "Let the next fellow do it", they say, and "pass the buck" on to posterity.

Occasionally, bridges have been built with a weak floor system, causing the stringers to sag under loads and the flooring therefore to loosen and rattle. Nothing is more annoying and trying to the nerves than to drive upon a bridge to the accompaniment of loudly rattling floor boards, announcing the passage to people far away. Additional stringers should be installed if the floor beams and trusses will permit,

and nail ties fastened to each one. Such stiffening will often eliminate troubles, and also strengthen the bridge by making the floor system as strong as the weakest truss. Such repair also reduces the impact stress, which is an important item especially in old structures.

Wood Truss Bridges Still In Service.

Old wood truss bridges are sometimes found in our cities which are surprisingly strong. Frequent inspection and occasional creosoting, with the replacement of rotted or decayed sections will serve to lengthen the life of these structures tremendously.

Piers and Abutments.

Attention must also be given to the condition of the piers and abutments of our bridges, that the weathering

of the stones or the concrete may not seriously affect their strength. Cutting out the decayed or weathered stones, and replacing them with rich and well mixed concrete, will often save serious trouble, while the extension or deepening of abutments or wing walls will sometimes prevent undermining by the stream.

Character of Approaches.

Greater carrying capacity can also be given to the structure by making pavements or earth roads on a level with the bridge at all approaches. Trucks dropping upon the bridge from a high earth road or pavement seriously tax its strength by introducing large impact stresses. The elimination of this source of trouble will not only produce smoother riding roadways, but will also lengthen the life of the bridge considerably.

It is found only too often that such conditions as described exist on our bridges. It is the city engineer's problem to have them corrected at the earliest possible moment, for one accident with its attendant possibility of loss of life as well as damage to property, may cost the city many times the price of repairs. Here again the old saying "a stitch in time saves nine" is particularly applicable.

V. ZONING AND THE CITY PLAN.

The creation of a City Plan, and the zoning of a city are very important to its proper growth. Millions of dollars are spent each year on new buildings in our cities, yet a large proportion of the amount is spent on structures which serve only to decrease property values in the surrounding districts. Much of this expenditure could just as well be so placed that benefits would be derived by all from its use, rather than damages. It is here again that the city engineer is vitally interested.

Zoning Compels Orderliness.

Zoning expresses the idea of orderliness in community development. Just as we have a place for everything in a well arranged home, so we should have a place for everything in our city. In what city can we not find gas tanks next to parks, garages next to schools, boiler shops adjacent to hospitals, stables near churches, or funeral establishments next to residences. Such misplacement of structures is to be strongly dondemned, yet some individuals feel greatly aggrieved if steps are taken to prevent their eredtion.

Proper Development of Land Encouraged.

The whole purpose of zoning is to encourage the erection of the right building in the right place. The man who develops his property wisely is protected from the damages caused by the man who cares not what is done with his land.

Zoning in the final analysis means the substitution of an economic, scientific, efficient community program of city building for wasteful, inefficient, haphazard growth.

Economies Effected Gain Favor.

The zoning of cities is rapidly growing in favor throughout the country, and has gained many friends through its effect of stabilizing property values, as well as promoting better health in the community. These two advantages alone should be enough to justify stringent laws governing the height of buildings, the location of residence and industrial districts and the percentage of the lot area permissible for building purposes. There are other features of zoning, however, that are of particular value and interest to the city engineer, and which eliminate largely the element of chance entering into his computations. Decided economies are affected thereby in the laying out of streets and in their paving, in sewerage and water supply, and in all municipal operations, for it is obvious that with the assurance that a given section of the city will be occupied by a certain definite class and size of buildings, the engineer can design much more intelligently the public works necessary to serve that section properly.

Problems of City Engineer in City Development.

One of the most serious problems confronting the city engineer in the opening of streets in undeveloped terri-

tory is the question of whether or not the district will be developed finally as a high class residential district, or whether the possible building of new transportation lines putting the land in close touch with the business center will result in an intense development of apartment houses; whether the district will remain a residence section or whether its proximity to rail transportation will change its character to factory districts occupied by the plants of great industries. All of these questions have a direct and vital bearing upon the design of streets, sewers, and other public services.

Zoning Assures Permanence in Character of Districts.

With a zoning ordinance in effect, and a definite plan existing, a street system can be developed with streets of such width and such distances apart as will best serve the use to which the land will be put, and with the assurance that such use will be permanent. Parks and playgrounds can also be located where they will permanently be of the greatest service to the greatest number.

Great Economies in Paving Costs Effected.

Perhaps the most apparent effect which zoning will have on public improvements, however, will be in its relation to the paving problems. As we have seen, in industrial districts durability and strength to carry the heaviest traffic is the first consideration, while smoothness, good appearance, and the absence of noise will govern the selection of a pavement

for a residence district. These considerations may be taken into account in planning such work with the existence of a zoning ordinance, but there is no assurance that the character of the district will not change, and the pavement as laid, be ruined by traffic heavier than that for which the pavement was designed. This has happened in many cities, with the resultant waste of many dollars.

Sewer Design Robbed of Uncertainties.

The effect of zoning on sewer design, with the substitution of known factors for estimates of future growth based on the judgment of the engineer, is very striking. Many dollars can be saved, and much later construction avoided, if such a city plan is in effect.

The length, depth and size of sewers are the three factors governing their cost, and are all affected directly by the character of the district to be sewered. Small dwelling house districts must be provided with sewers in every alley. Connections may be expected nearly every 25 or 30 feet. For apartment house and light manufacturing districts, however, connections may be placed farther apart, while for large industrial plants, sewers may only be required occasionally.

Small dwelling houses and industrial buildings seldom have cellars more than 5 or 6 feet below the surface of the ground, necessitating only shallow sewers, while apartment houses, commercial buildings and the like require much deeper sewers. The necessary size of sewers, being governed

partly by the number of people served, can be determined with great accuracy after the grade is established, for the permissible height of the buildings and their density in a given area are already known to a certainty. For storm water drains all the factors such as the proportion of pervious to impervious areas, slopes, etc. become fairly definite quantities permitting the building of adequate sewers without guesswork and possible waste. All

All of these items and many others are of great value, and when known, often result in a saving of 10 to 15 percent or more of the cost of the drainage structures. Growing cities, therefore, cannot afford to be without a definite city plan and a zoning ordinance, and the city engineer cannot be other than one of the foremost advocates of their adoption.

Powerful City Plan Commission Needed.

A City Plan Commission composed of broad-minded, well educated men, backed by the advice of well trained city planning specialists, is a necessity to the proper growth of any city. This body should not be established merely for advisory purposes, but should be clothed with definite regulatory powers, that their work may not be for naught. A city so equipped is much better able to handle its growth and development, that in future years, damage and loss will not result from unregulated building.

VI. THE CITY ENGINEER AND THE BOARD OF LOCAL IMPROVEMENTS.

The successful city engineer, and especially he who is the engineer for or a member of the Board of Local Improvements, must become thoroughly acquainted with municipal law, and particularly with that part of it concerning local improvements, in order that his work may not be the cause of adverse court decisions on local improvement ordinances.

Competent Legal Advice Indispensable.

The paving of streets, the construction of sewers, the installation of ornamental street lighting systems, and work of similar character is largely done in our cities by special taxation or by special assessment. Legal action necessary to carry out these plans varied in different states, while in Illinois the local improvement laws under the authority of which this work is done are very strict as to every detail. It is not in this, however, that the difficulties are alone found, but it is in the records of the Supreme Court that the engineer finds his stumbling block. Decisions handed down at various times concerning disputed points in the law often change completely the apparent meaning of certain sections, so that the engineer, to be safe, must be guided by the advice of legal specialists in these matters.

The Engineer in Law.

Contrary to the ideas of the layman, the engineer has no standing in law as an authority in these cases. He can be given no discretionary powers whatever in the construction of an improvement, but must follow out to the letter the terms of the plans and specifications, with no variance.

The Board of Local Improvements is constituted the sole authority in these matters, so that all things must be referred to them for action. The decision as to whether material is satisfactory and complies with the specifications, is left to the Board. The decision as to the adequacy of methods of construction is left to the Board, and the final acceptance of the improvement is subject to the approval of the Board. The Board of Local Improvements constitutes the supreme authority, and its actions are subject to review by the courts only in case it has not carried out the improvement according to the ordinance concerned.

Plans and Specifications Important.

Plans and specifications must be complete in every particular. All dimensions and measurements must be shown plainly, while all private property necessary to be taken for the improvement must be shown and described in detail. The engineer is not allowed to leave things for granted, for such omissions may invalidate the whole proceedings if anyone concerned should decide to contest the work.

Estimate Must be Complete.

The engineer's estimate is an important document. In it, each item to be done must be listed and described completely, including all component parts. In it, likewise, nothing may be omitted, but rather all important dimensions, kinds of material and proportions, together with the fair estimated cost must be stated or described.

In the keeping of the records of the proceedings of the Board, care must be taken to comply strictly with the law as interpreted by the courts. Safe practice requires strict adherence to every detail, that discrepancies may not be found, and that the satisfactory progress of the work may not be hindered.

Continual Care and watchfulness is the price of safety and even then, in Illinois, the improvement cannot be considered safe from sucessful legal attack.

VII. THE ENGINEER AS AN EXECUTIVE.

In many cities where the engineer is given charge of all public works, responsibilities are thrown upon his shoulders which require the possession of certain characteristics or abilities which cannot be obtained from books. He must be well versed in the administration of his office and in the technique of his work. He must be able to decide unerringly, questions of procedure, equipment and organization, and as a result, the final decision upon many questions falls to him. This in itself is a problem of some difficulty and importance and upon its correct solution depends the smooth and satisfactory operation of his department. He should be allowed and required to administer the affairs of his department in all details, and should be held responsible for results.

Requirements for Success.

Certain qualities of character and mentality are necessary for success in this work and should be possessed in good measure by the engineer. Loyalty is the first and most important quality - loyalty to the interests of the public which he serves - loyalty to his superiors, sympathy with their purposes, the things they try to accomplish, and the methods which they use in accomplishing them. He is loyal to his task who places the success of his work above that of his own personality - who is not always scheming for

his personal gain, but who rather considers as his reward the doing most efficiently the things he undertakes.

Integrity should be placed next in order- without which he is worse than useless in any position of trust.

As a third asset, industry or honesty of effort is an essential. High standards of living and greater expenses are constantly compelling city governments to undertake new duties and to find better and more economical ways of doing old ones. Expenses of government are constantly increasing, debt limits and limits of taxation are dangerously near or already attained and additional taxes are vetoed by the general public. The engineer, as head of his department, therefore, must not only put forth his utmost efforts in the performance of his duties, but must be active in keeping in touch with what others in his position are doing. Keeping up with the times or one jump ahead of them will keep him on the go continually and he will find it often necessary to extend his working hours far beyond those of his subordinates.

Fourth on the list of requirements is education and experience. Natural ability and aptitude may help one greatly in the performance of his duties, but education and experience are indispensable for the engineer as head of his department.

Tact and Diplomacy Needed in Public Life.

The possession of tact, unlimited patience and good

nature is essential in his dealings with the general public. It is the public's business in which he is engaged, and it is his business, and through lack of information or through wanton misinformation, his official acts are often likely to be misjudged. On the other hand, his reputation and influence in the community, his success in his undertakings, and incidentally his tenure of office often depends upon the good will of the public. It is necessary, therefore, that from all standpoints, his attitude toward the public should be carefully considered. He should always be courteous, showing no distinction between rich and poor, wise and the ignorant, friend and foe. Snobbishness or superciliousness will never gain him friends, but will rather cause him to lose the good will of those with whom he comes in contact. Fairness and firmness instead must characterize all his dealings, that the favor of the public may be retained.

Cooperation of Subordinates Valuable.

Tact in dealing with subordinates is also of importance, for without it, he will lose their full cooperation and enthusiasm in their work. With these things, many a large undertaking has been carried through successfully, and in most cases the success has been the result of the use of tact and consideration by the head of the organization in his treatment of its members. Enthusiasm of his men for success is the greatest asset any executive can have, while his path is doubly difficult to travel if he lacks

a proper appreciation of the importance of this item. Extreme patience is sometimes necessary, but it is the duty of the engineer to make every visitor his friend and a defender of his administration.

It is obvious, therefore, that the city engineer's problem is one composed of many problems. It is one which for success requires the possession of many of the qualities and characteristics of the executive, as well as the knowledge and ability for clear thinking and logical reasoning of the engineer. Every engineer cannot hope to become expert in all branches of the municipal engineer's art, His aim should rather be to become thoroughly proficient in one kind of work, and yet to have a fair knowledge of all the others. The city engineer, by profession, can almost be classed as a "jack of all trades", although for ultimate success he must be master of one. His work is pleasant, yet varied. He is practically his own "boss", yet he must guard against acquiring habits of laziness and procrastination which seem peculiarly prone to attach themselves to public employees. Most of all, he must have a character beyond reproach - he must be scrupulously honest, that the stigma of "graft" may not be placed upon his name and reputation, and he must be open and aboveboard in all of his transactions, that his reputation for honesty and fairness, for being a gentleman of his word, and for being above all, a good engineer, may not be questioned.

APPENDIX

AN ORDINANCE REGULATING EXCAVATIONS IN STREETS AND ALLEYS.

Section 1. No excavation or trench shall be made in any street, avenue alley or public ground in the city of X for any sewer, drain, water, gas steam or heating pipe or for any other purpose not otherwise provided for by ordinance, without a permit. Permits to make excavations or trenches shall be issued by the City Engineer only to such persons, firms, companies, or corporations as have executed and delivered to the City of X a bond with sureties to be approved by the City Council which shall terminate at the end of the municipal year for which it was given. Said bond shall be in the penal sum of $1,000.00 and shall indemnify and save harmless the City of X from any liability on account of accident or damage caused by making any excavation or trench in any street, avenue or alley or public place of the city, and to provide for the replacing of the ground removed in making said excavation or trench in any unimproved street in as good condition as it was before being removed for the space of twelve months thereafter, and to provide that the person so opening any unimproved alley, avenue or public ground in case the same settled, in such manner as may be directed.

Section 2. Before any permit shall issue to dig up or open any paved street, avenue, alley or public place, the applicant shall in addition to the conditions prescribed in the foregoing section, deposit with the city clerk of the said city a sum of money sufficient to cover the expense of

repairing or replacing the same in as good condition as before the same was dug up or opened, together with ten per cent additional to cover the cost of inspection, supervision and other incidental expenses attendent thereon. The amount of said deposit shall be ascertained by the City Engineer for the lowest sum for which such replacing or repairing can be properly done, and which shall in all cases be done by the city under the supervision and direction of the City Engineer, and the cost thereof to be borne by the person, firm or corporation upon whose request any such paved street, avenue, alley or public place was dug up or opened. In case the estimate exceeds the cost of repairing or replacing the same in as good condition as it was before being removed, plus the aforesaid ten per cent, the difference shall be rebated to the person, firm or coporation upon whose request the permit was issued.

Section 3. When said trench or excavation is ready to be refilled or repaired the applicant shall give the City Engineer not less than twenty-four hours notice and it shall then be the duty of the City to immediately refill and repair said street. And in making such repairs said trench or excavation shall in all instances have constructed above the same a concrete slab, re-inforced as the city engineer may direct, of dimensions at least one foot larger on all sides than said opening in the street, and in case the surface of the street is paved, that upon said slab of concrete the street surface shall be repaired and replaced the same as the balance of the street.

Section 4. All opening made by any applicant or his agent in any improved street shall be protected at his risk until the limit of the twenty four hours notice hereinabove provided for shall have expired. The following rules and regulations are hereby approved, to-wit:

Rule 1. Trenches in public streets or alleys shall be excavated so as to impede the public travel as little as possible. The crossing of gutters and all waterways shall be left in such shape as to admit the ready escape of water during storms. Planks shall also provide where the sidewalks or crossings are open, so as to facilitate easy crossing over the trenches.

Rule 2. Red lights shall be kept around all unfinished work at night, and fences or other suitable and sufficient barricade shall at all times be placed around the excavations on paved street or alleys or other places where accidents are likely to happen.

Rule 3. Work in public streets must not be unnecessarily delayed, and, when directed by the City Engineer or the street and alley committee the number of workmen shall be increased to hasten the work as shall be deemed necessary for public interests.

Rule 4. Trenches in depth of six feet or over, and in all made or other treacherour soils, or near large brick building walls, shall be properly braced, and the party excavating and his bondsmen shall be liable for all damages by reason of neglect in this respect

Rule 5. No tunnels or excavations shall be made under any street or pavement except by authority of and under the direction of the City Engineer.

Rule 6. The refilling of excavations and trenches for the distance of fifteen (15) feet on each side of the center of all unpaved streets and avenues shall be well and thoroughly done in uniform layers of not exceeding nine inches, and tamped with a tamper of not less than forty pounds weight, or filled with puddled earth, as may be decided by the officer having charge of such work or the inspector assigned to such duty, so as to replace all excavated material and leave the surface in as good condition as found before commencement of the work.

Section 5. For all permits under this ordinance a fee of $2.00 shall be charged payable to the City Clerk except when such connection is made with any city sewer for which the applicant has already paid the fee required for that purpose, and except in case where the connections are ordered to be laid by the City Council preliminary to laying a pavement and where such connections are laid only to the curb or sidewalks line and not into the property.

Section 6. Any person, or persons, firm, company or corporation who shall violate the provisions of the foregoing ordinance, or shall make any excavation without the permit required herein, or shall be guilty of any other violation thereof, shall be fined not less than $10.00 nor more than $100.00.

Section 7. All ordinances or parts of ordinances in conflict herewith are hereby repealed.

Section 8. This ordinance shall be in full force and effect from and after its passage and approval and publication as required by law.

AN ORDINANCE RELATIVE TO THE CONSTRUCTION OF CONCRETE SIDEWALKS.

Section 1. That all persons, partnerships, firms or corporations engaging in the construction of concrete sidewalks in the City of X shall obtain a license from the City Clerk before doing any work in said city, and that the cost of said license be $2.00 to be renewed each year.

Section 2. That in making application for said license, the aforesaid person, partnership, firm or corporation otherwise known as the contractor shall agree to abide by all rules and regulations set forth in the ordinances of the city of X relative to the construction of concrete sidewalks and shall guarantee all work done against disintegration or damage due to faulty workmanship or materials, for a period of three years.

Section 3. That before a license may be issued, the contractor shall file with the City Clerk a bond in the penal sum of $5000.00, with sureties approved by the City Council, to be paid to the City of X, conditioned upon the satisfactory performance of all work, indemnifying and protecting the City of X from all accidents and damages caused by any negligence in doing work or by any unfaithful, imperfect or inadequate work done under the authority of said license, and guaranteeing to replace and restore any imperfect work which may be discovered within a period of three years from the time of its completion by the aforesaid contractor.

Section 4. That the decision of the Committee on Streets and Alleys of the City of X that the sidewalk is imperfect and needs repair, shall be final.

Section 5. That all persons, partnerships, firms or corporations otherwise known as the contractors hereafter engaging in the construction of concrete sidewalks in the City of X, shall in addition to taking out a license and filing a bond, as hereinbefore provided, shall deposit with the City Comptroller the sum of $200.00 in cash, which must remain with the Comptroller for a period of four years after the contractor discontinues business, as a fund to guarantee the repairing or rebuilding of defective walks. Should the contractor fail to make repairs as required by the Committee on Streets and Alleys within fifteen days after being notified, the Committee on Streets and Alleys shall cause said repairs to be made, the cost of which shall be paid from the aforesaid fund, and by action on the bond, if the fund is insufficient. If such repairs are made by the Committee on Streets and Alleys from the aforesaid fund, the Contractor shall be barred from doing further work until such time as the contractor shall pay into said fund, the amount deducted for the cost of repairs as made.

Section 6. That all contractors constructing concrete sidewalks shall imprint in one corner of one square of each fifty feet of walk constructed, their name and the year in which said walk was completed, and the matter required to be printed in said walk by this provision shall not take up

more space than one foot square.

Section 7. That after this ordinance is in full force and effect, it shall be unlawful for any contractors to engage in the construction or repair of any concrete sidewalks in the City of X without first complying with the provisions hereof, and whoever violates any of the provisions of this ordinance shall be fined in a sum not less than $5.00 nor more than $50.00 for each and every violation hereof.

Section 8. All ordinances or parts of ordinances in conflict herewith are hereby repealed.

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